Toyota Handbook

1973 Edition

Edited by Mark Warren

2019

As a researcher, I am curious whether you found this work useful, what industry you are in, what country, and whether you are working in a small, medium or large enterprise.

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Table of Contents

Acknowledgements

To the best of our knowledge, the original content of the 1973 TPS manual[1] was written by the staff[2] of Toyota Motor Corp. (OMCD - Operations Management Consulting Division)

Art Smalley was my source for finding a copy of the 1973 TPS manual in Japanese. While the early machine translations were very interesting, many details could not be translated and the nuances that a native speaker would understand in the implied message, were missed. A special thanks to the translators, Marie Yasunaga and Abdulrahman Zahran for providing critical insights into the content of the manual. Lean expert, Michel Baudin provided additional insights on the manual translation and Franck Vermet on simplifying and clarifying the content.

About a decade ago John Shook challenged me to understand what Taiichi Ohno did differently with the TWI programs. This led to the need to test applying all the TWI programs as a group, rather than as single programs.

Dr. Vivek Nagarajan, with the PSG Institute of Management, found many companies willing to host a small team for two weeks, four hours a day. The training was split between teaching theory and shop floor implementation. The goal was to immediately apply the TWI skills and learn how to transfer the skills effectively. Thanks to Roots Cast, TVS, Pricol, L&T, LGB, and the many other companies that hosted our visits. I cannot forget Hari Prasad's tireless efforts behind the scenes and his practical notes as an intern following the experiments.

The next level of understanding would not have been possible without the support of the Rang Dong factory hosting multiple visits. The first visit took place during their peak season, yet the supervisors and managers found time for coaching and running experiments to solve problems and improve their processes. We tested on multiple lines, simplifying the process of organizing for flow. They have about 50 lines that range from automatic to manual; electronic surface mount lines (SMT), semi-automatic through hole (THT) and manual insertion of circuit boards, assembly of hundreds of different types of lights (refrigerator light to street lights), metal forming (for light frames), and plastics (extrusion and blow molds). Duc Nguyen was instrumental in getting support from the board of directors, organizing the first teams of volunteer managers and supervisors, to daily participation with various teams to monitor progress, and acting as one of the primary translators.

[1] http://www2a.biglobe.ne.jp/~qpon/toyota/kanban/text/

[2] Ohno's direct reports in the 1950's – K. Suzumura, I. Watanabe, M. Morita, Y. Arima

Introduction

By 1970, Toyota had a fairly stable production system internally and they made a decision to assist suppliers by sharing their knowledge and skills. To do this, Toyota created a special internal improvement group called Production Research Division (later renamed Operations Management Consulting Division – OMCD).

The sharing of TPS started with 17 suppliers, some captive, in 1970. The decision was probably because their external suppliers were the primary contributors to disruptions to flow inside Toyota; caused by quality problems, late deliveries, etc. Their initial objective would focus on creating stability, rather than putting into place the structure that created their own system.

Ohno had resisted putting anything in writing about TPS, so the implementation of the knowledge and skills was haphazard. The difficulty in sharing the thinking behind TPS and their habit towards standardizing all work may have been the driver to codify the thinking behind TPS. By 1976 they had developed a structured introduction and implementation process.[3]

This 1973 manual was also used as course materials by Ohno and his team – the Japanese Management Association compiled their workshop materials and released it as a book in the 1978. Productivity Press translated it and released it as ***Kanban: Just-in-time at Toyota*** in 1986. While much of the Productivity Press book consists of the same materials as the 1973 TPS Manual, it is not presented in the same order.

This is an annotated version (draft) that was translated from Japanese, so you can have access to the same sort of explanations behind the ideas as the original suppliers.

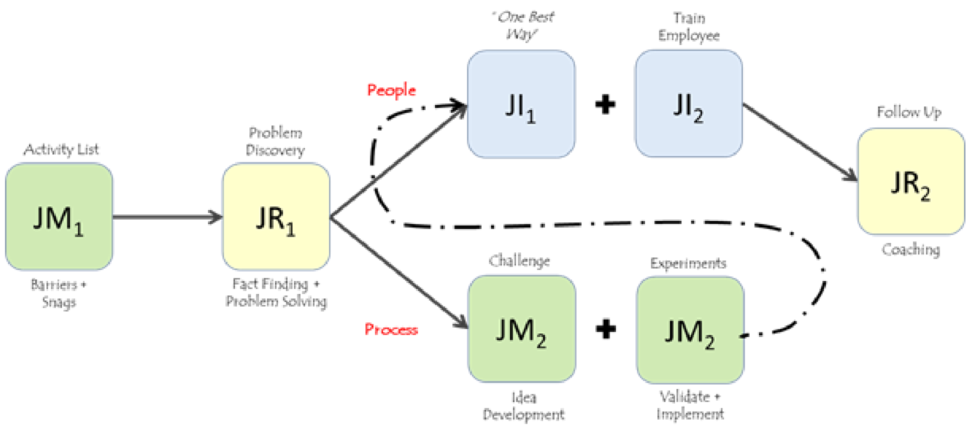
Translating and editing this manual was just one step in the journey to better understand how Taiichi Ohno developed Toyota's production system. While the manual provided some clarity, it also became clear that there was far more background information needed for successful implementation.

The TWI skills are briefly mentioned specifically, and elements of the programs are just below the surface throughout the TPS Handbook. The journey to piece together a simplified roadmap where we can replicate Taiichi Ohno's progress in his development years (1950-1965) has taken nearly as long, even with all the '*lean*' literature available. The time-consuming part is not getting a company to '*look like*' Toyota or '*look lean*', it was to understand the core principles through actual implementations and test whether our guesses were correct (scientific method of testing your hypothesis).

[3] "*Toyota Kaizen Methods: Six Steps to Improvement*". Isao Kato and Art Smalley. Authors of the TPS manual are thought to be F. Cho, K. Sugimori, S. Uchikawa, and edited by Isao Kato.

We found many layers of learning were hidden in Ohno's journey before the intensive growth period of 1950-1965. This includes his understanding of the flow principles as well as his implementing the TWI skills to build the foundation for standard work. Experience made him a pragmatist when working towards his ideal; "*…for someone who is striving for rationalization, everything becomes about implementation, or a challenge about how close you can get to it*."

Knowing the hidden layers (develop awareness, build understanding, create standard, develop improvement, and follow up) will improve your odds of success.



Practice Rather than Theory

Practice Rather than Theory
論 よ り 実 践

Managing Director
専務取締役

大野耐一
Taiichi Ohno

What I have tried variously over the years or has been mainly organized by many people, I think that it is hard work, reading this now.

The late president, Kiichiro Toyoda remarked, for such general industries, automobile assembly work is best for each part to gather at the line side *"Just-In-Time"*.

When you try to perform such an obvious thing, you will collide with various problems, making it quite unfeasible. Even if ideals are like that, if we say that they are unrealistic ideals, then that is all they can be.

Considering that the character “理 (logic)” in “合理化 (rationalization)” is the same “理” from “理想 (Ideal)”, for someone who is striving for rationalization, everything becomes about implementation, or a challenge about how close you can get to it.

Just in time, productivity, cost, and shifting the burden towards outsourcing; judging from common logic, all of these are thought to be full of contradictory aspects. We must break this wall of common logic and make those mutually contradictory points coexist through what we nowadays call “*logic escape*.”

"Just-In-Time" was translated for the workplace as, "*Go get what you need, in the amount you need, when you need it*" (department you need).

The following process goes to pick up from the preceding process, as it is the maker who supplies outsourced parts, we indicate the number to be supplied as well as the delivery date. This is the fundamental idea of the Toyota Production System, and this idea was realized by expanding it in various forms.

As a preliminary step, production corresponding to this must be done most economically. In the preceding process (the production workplace), quality, quantity, and cost can easily be considered separately. For quality or for securing quantity, it is easy to place emphasis on the quantity, especially if cost is emphasized.

In the past, I called the technique of balancing these three (quality, quantity, and cost) "*workplace technique*." Some call it "*manufacturing technique*". Recently, I also referred to the "*Toyota-style IE*" as "*MIE* (Moukeru IE)".[4]

Putting names aside, since some parts of this system are far from conventional general wisdom (common sense), doing it in a halfway manner would easily give the opposite effect instead, so it must be carried out thoroughly. I must change my way of thinking and perspective.

Just like how most magic tricks have their own techniques, this workplace technology has its tricks as well. If I were to reveal that trick, I would say that it is the repetition of "*eliminating unnecessary activities – and doing it thoroughly*," "*developing eyes that can find the unnecessary activity so that you can eliminate it*" and "*thinking of the method to eliminate the unnecessary activities you have found*." Never waning or letting up, no matter how long it takes you, no matter how far you must go.

[4] Translator's notes - MIE is a short for "*Moukeru IE*", or "*Moukeru Industrial Engineering*". The verb "moukeru 儲ける" means "*to make money/profits*." In Japanese, a verb modifies the noun that follows it, making the over meaning "*The industrial engineering of making money*."

Chapter 1

Section 1 - Toyota Cost & Labor Reduction Method

The basic ideas of the *Toyota Production System* (TPS) is a sequence of operations with an objective of improving productivity by reducing unnecessary, unreasonable and uneven activities, thus decreasing our production costs.

Although its underling ideas are based on general Industrial Engineering (IE) theories, these fundamental ideas were developed over a long period of time exclusively for the improvement of the production system of the Toyota Motor Corporation. It is not a simple application of Industrial Engineering theory.

Rather than merely listing facts about the fundamental ideas in this section, we would like to review the characteristics of TPS and demonstrate a few of its concepts.

Company-wide IE Directly Connected to Management

Much has been said about production management systems; there is no single method for *"How to Make Things"* that would work for every production process for all types of products.

Accordingly, some companies could make a product using a single person, another would use two people, while a company that is completely unconcerned with production methods would produce it using three people.

In the last case, the company which used three people would likely have more warehouses, vehicles, pallets, conveyors, and other equipment. This can cause an increase in the number of indirect employees and production cost could be double (or more), making a vast difference in profits (if they are profitable at all).

We do not have concrete statistics that clarify this relationship; we can imagine that such difference happens in many companies. This difference will not only be a matter of the present situation, every single year, investment will be repeated in a similar way because the annual plans are designed based on the thinking that created the current situation.

Once the fixed costs (manufacturing plants, equipment, machinery, etc.) have been invested, these fixed costs are unrecoverable, even if they later turn out to have been unnecessary. Considering the serious risks of over investment, this is a significant issue for any company.

The only way to avoid the risk of over-investment is to continuously improve the production efficiency in every aspect of the operation process, reducing the basic units of consumption for labor, equipment and machinery. Then reflect these improvements in the production plans for the next phase.

Looking at things from this perspective, Industrial Engineering will have a major effect on business management. Companies that do not practice IE sufficiently are like splendid castles built on sand. The company may look successful during times of economic expansion, but during economic contractions, they can collapse as if hit by a typhoon or an earthquake.

The productivity improvement routines are an essential foundation of the corporate management system for Toyota. All departments that are involved in production handle things in the overall most effective way. The production system is based on the following concepts:

Leveling Production Plans.

If you think solely about the production efficiency at the final assembly plant, you may think it is most efficient for the plant to run only one product; this would rather result in unnecessary activity in the preceding stages of production.

Minimize Lot Size

Lots should be minimized in typical lot production processes, such as using a stamping press. This is not just about the inventory piling up or increasing the labor for transport, but there is a risk of experiencing a stock-out, caused by mistaking order priorities. And the capability of the processes could be misjudged as insufficient, which would then lead to an unnecessary extension of production lines.

To enable small lot production without causing a reduction in your production capacity or adding costs, it is necessary to improve your changeover capability.

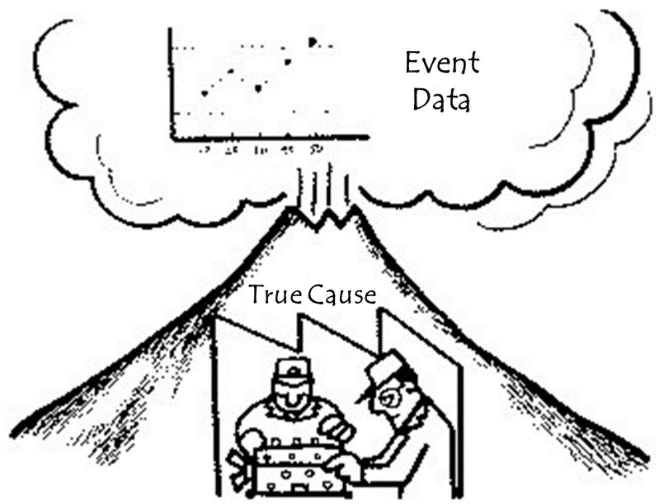
Just-In-Time

Produce only the required items, at the required time, and in the required amount. The aim of this is to reduce the unnecessary activity of overproduction, as well as to allow you to visualize the surplus capacity at that moment.

Scientific Attitude

In the workplace, problem solving must clearly follow the following steps: the actual situation is the starting point, investigate for root cause, and then develop a solution. When it comes to the workplace, facts are regarded as most valuable.

For example, regardless of how much data you are shown, it is difficult to grasp the actual situation of the workplace from data. If a defect occurs, finding it out from data (*reports*) would mean a delay in taking countermeasures. Even worse, due to misrecognition of the true cause of the failure, you may also fail to prevent the recurrence of the failure.



There is no place better than the actual workplace where you can grasp the real situation properly of what is happening there. When there is a failure, you can contain it immediately; it is easier for you to find the true cause and take immediate measures.

In TPS, when it comes to the workplace, we regard the real facts to be more accurate than data.

When you have a problem and your process of finding out the root cause is insufficient; the countermeasures you design will also be out of focus. That is why it is necessary to use the 5-Whys method, and ask yourself "*Why, why, why…,*" until you find the root cause.

To make this method work, you should keep the following points in mind:

Make Details of the Problem Obvious

If the problem is known, it is relatively easy to implement countermeasures. The hard part is finding out what the real problem is. That is why we use various tools to signal a problem.

Objective of Problem-Solving should be Clear.

Improvement is based on need. The root cause must be identified, and then solved. Countermeasures taken without fully investigating the root cause would be merely a provisional measure, which does not lead to the prevention of reoccurrence of the problem.

Take Countermeasures for Every Single Failure

Even the failure occurs only once in a 1000, when you have facts, you can investigate its cause, and take preventive measures. It is vital to be able to spot the infrequent defects that are likely to go unnoticed.

Be Practical

There are two aspects to being practical. First is the approach should have step-by-step measures. You can set a high goal, but your progress toward this goal should be performed step-by-step. The second is to attach importance to results.

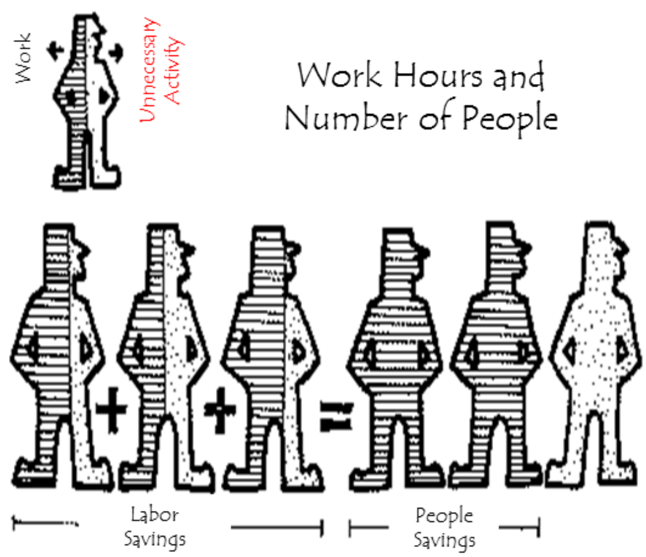
Based on these ideas, we think as follows:

Start from Work Improvement to Equipment Improvement

General sequence is, people improvement (training), then process (including layout), then equipment, then design. (More details in Section 6)

"Man-hours", "number of people", "labor cost saving" and "labor saving"

In calculations, you can say 0.1 hour, or 0.5 hour saved. However, you still need one person even for the work of 0.1 hour. If a job for one person is reduced by 0.9 hours, this would not result in a reduction in labor costs. Only when the number of people is reduced, will true cost reduction be achieved. The improvement of labor must focus on reducing the actual number of people needed.[5]



In the case of introducing automated equipment, if you achieve 0.9 person's work worth of labor-reduction, 0.1 person's work remains (*often for keeping an eye on the machines*), then no reduction in people will be achieved despite the investment in equipment.

[5] Reducing the number of people should be put into context. When Taiichi Ohno began actively developing TPS, Toyota took about nine times as many people to produce a vehicle as Ford. You will see a strong theme throughout TPS for improving the efficiency of production and they do this by counting the number of people it takes to do the job.

This is sometimes referred to as labor-saving; a reduction of the number of actual working people that leads to a practical cost reduction is differentiated from "*labor-saving*" and is called "*people saving*".

The Difference between "*Automation*" and "*Autonomation*"

With *automation* a machine may run by itself, yet still need a person watching it to stop the machine when something goes wrong. When *autonomation* is added to the machine, it can detect the same problems that the person guarding the machine would do, and automatically stopping the machine when a problem was detected (details in Chapter 2).

Checking is Reflection

The improvement is finished when the intended results are obtained. When you do not get results, it is often because of unfinished work.

Try the improvement idea at the workplace to see how it performs; check the results; improve the things still not working correctly, and then check again. By repeating this process, your improvements can provide favorable results.

The checking process is a step to reflect on the results of your work, rather than simply implementing ideas.

Economic Efficiency is the Criteria

The purpose is the reduction of costs. The basis of the assessment is *"whether this is economically beneficial or not?"* As for practical thinking, we have the following points:

The operation ratio of equipment is decided by the required production amount

This is emphasized to prevent falling into the wrong way of thinking about the sunk cost concept which suggests that you must make full use of facilities that have already been purchased, or else it will lead to loss.

For the same reason, in the case of multi-machine handling, we follow the same concept in focusing on the work of people, not the machines.

(More details are discussed in Section 2 as well as Chapter 2)

Spare Capacity Allows you to Practice

People who have fixed work hours will receive the same salary whether they have nothing to do (*pretending to work*) or practice improving the setup process when they have no useful work to do. (More details in Section 2)

Clear Position of Workplace

We regard the whole workplace as a single organism. The workplace is not, just a group of hands that have entrusted their brains to management. Essentially, the workplace should play the main role. It is unacceptable for engineering to act as the boss for the actual workplace. What is important is to emphasize the autonomous action of the workplace.

To this purpose, the engineering division should fulfill its role by supporting the weaknesses in the actual workplace where they lack information or skills. They should do this without weakening the responsibility at the workplace.

Emphasize the Capacity of Adapting to Change

Plans may often change; what matters is having a production system that can adapt immediately when plans change. An adept workplace capable of handling that.

Section 2 - Labor Reduction and Cost

The objective of labor reduction is cost reduction.

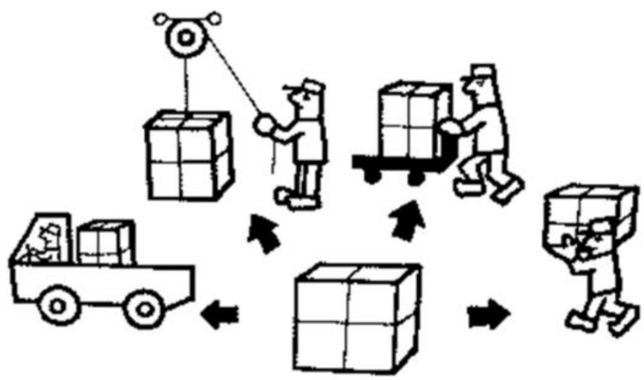
In this section, we will talk about the relationship between labor reduction and cost reduction, while focusing on the concept of *economic efficiency,* which is the "*basic idea*" of Section 1.

Toyota's labor reduction effort is a company-wide activity concerned with the workplace, whose purpose is cost reduction. All the various concepts and improvement policies, must ultimately lead to cost reductions. All evaluation criteria are decided based on whether they can achieve cost reductions.

Problem of deciding which is more beneficial; A or B.

Consider the case of deciding where, if we pick option **A**, we cannot pick option **B** (or possibly the other way around). In this case, we decide based on whether **A** or **B** is more beneficial for everyone in Toyota.

There might be one objective, but there are many ways to meet the objective. For example, when we consider which is more effective: maintaining the current method of production or doing it with one less person.



There are many ways to meet an objective

Problem of selecting from numerous choices.

For "*reducing people*", there should be many approaches available. We must investigate which one among these is the most beneficial. Sometimes multiple choices occur independently; and the evaluations may occur separately, after testing the improvements, consider them relative to each other.

Sometimes there is improvement where **B** is not sufficient. If the investigation of **B** is not sufficient, this generally leads to an unreasonable improvement plan (one that costs more money.) Even though, such a plan is still valid relative to **A** and thus seemingly advantageous as a whole; it may cause rather bad results.

For example: There was a plan to reduce the number of people by one, when we installed an electric controller that costs ¥100,000. If we carry out this plan, since we could reduce the number of people by one for the cost of ¥100,000 and claim that it was a big profit for Toyota.

After you consider the other options carefully, you may find out that one person could be reduced by changing the work procedure without investing any money. Then the plan to improve by spending ¥100,000 is not a success, but a failure of rushed decision making.

We do not do just anything because it is profitable. Instead we must go for the plan that we believed to be the most profitable among all the other profitable options. We have pay close attention, since this is a mistake one is easily prone to make when introducing autonomation.

Unnecessary Activity Increases Cost

The basic concept of TPS is to improve the productivity by eliminating unnecessary activity. We believe it is not necessary to explain how this helps in reducing costs at this point, but when it comes to how much it helps, interpretation varies according to each person. With that in mind, we shall explain how we believe unnecessary activity affects production cost.

If we are to borrow a phrase, the definition of *"unnecessary activity in the production workplace"* would be the factors which *"only increase cost."* For example; too many people, excessive equipment, too much inventory, and the like. Anything that exists more than needed, be it people, equipment, raw materials, or products, are only increasing the cost. In addition, this unnecessary activity causes further unnecessary secondary activities.

For example, if there are too many people, you may be tempted to create some work for them to do. The power and materials consumed for this labor can be considered as secondary unnecessary activity.

The largest unnecessary activity is caused by overstocked inventory. Take a closer look at this example. Suppose we have more inventory than needed. If all of it cannot fit in the factory, then there will be a need to build a warehouse. Then we will have to employ people to transport it to the warehouse, and we will have to buy a forklift (or truck) for each of these people. We would also need to allocate some people to the warehouses to manage the inventory and protect it. After doing all that, scratches, rust, or other damage are likely to occur. Then you need people for repair work.

Knowing what you have and how many is time consuming. This drives the need for considerable labor in the materials management department. When manual tracking reaches its limits, someone will come up with the idea of installing computers to manage the inventory.

If you know what you have and how many, when you have shortage of products you will start thinking that the production capabilities must be insufficient because a stock-out occurred even though it is produce it daily. Then expansion plans are placed in the capital investment for next fiscal year. Once the new equipment is introduced, we will have even more inventory to manage.

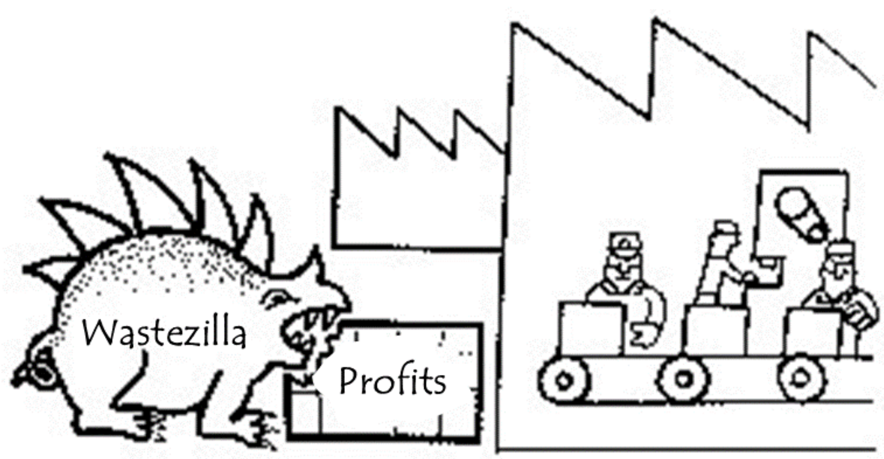
All the additional people, forklifts, pallets, manufacturing plants, computers, and equipment we mentioned here could be unnecessary. These are secondary things that were added all because of unnecessary inventory. This is all unnecessary if there were no such excess inventory.

Such an example is an assumption of the worst-case-scenario. Occurrences like this can happen anywhere at different scales. It can easily happen right away if we get a little careless. It is difficult to determine what is necessary and what is unnecessary; some details are hard to notice. Considering the magnitude of the impact, it is important to give close attention daily.

As shown in the earlier example, mistaking the order of priorities, ending up with a stock-out, and assuming it to be a lack of capacities, ultimately leads to investing in unnecessary equipment. A mistake that is difficult to undo.

The primary and secondary unnecessary activity described above, will be included in the direct labor costs, depreciation costs, general and administrative expenses, thus increasing the entire production cost.

When we think this way, we cannot ignore the parts where unnecessary activity causes an increase in cost. A mistake like this could cause unnecessary activity to eat away the profit we make, which could compromise management itself.



This way of perceiving cost underlies the objective of TPS regarding cost reduction. We emphasize elimination of unnecessary activity, because we believe that by reducing inventory and people, clarifying the surplus capacity of the equipment, and by removing the secondary unnecessary activity, will lead to cost reductions.

Concept of Economic Advantage

In Section One, we explained the basic idea of how we think and practice. All the decisions are based on the question, *"Is this going to reduce costs or not?"*

In the following section, we will look at the concept of TPS from the "*economic engineering*" point of view and discuss what is economically advantageous.

With and Without Reserve Capacity

Economic advantage varies from situation to situation if there is a surplus in production capacity or not. To put it simply, in times of surplus, we use people who have nothing productive to do, and the idle machines, so there is no additional cost.

(A) The problem of in-house production or outsourcing.

There are many cases where we compare the costs of producing an article in-house or outsourcing it. If there is spare capacity for in-house production, the actual additional cost is only the variable costs such as materials and consumables. Accordingly, in-house production would be beneficial without even needing to compare.

The same can be said about the following example:

If a transport operator is waiting beside the line until the pallet is full, assigning them some line work or preparatory work will not create additional costs. This is obvious without making investigation into the profit and loss. It is a mistake to think that this labor improvement will raise your labor efficiency.

(B) The problem of making smaller lots.

If there is a surplus in general-purpose machinery such as presses, putting the problem of shortening the setup time aside, it is best to keep lots as small as possible when producing something.

If you cannot reach the scheduled time, use the time to the practice changeover improvements, which is more profitable than doing nothing. The reason for this is the same as (A).

If there is surplus capacity, there is no need to investigate cost since profitability is clear as it can be. What matters here, is to always make it *obvious* when we have surplus capacity. If the surplus capacity is not obvious, this can lead to misjudgment and increase the cost.

We take this one step further in TPS and put effort into improvements that squeeze out the surplus. If there is surplus capacity, it may be considered as '*free*'.

Sunk Costs

Costs and expense that have already been paid are irrelevant to plans or measures in the future. When you think about improvements, it is a mistake to think that this is the constraint condition.

Looking at it from the other side, we cannot evaluate the effectiveness of the special-use equipment, devices, and pallets, which have been economized by the improvement activities. It is only too clear that they were once unnecessary activities.

We should take advantage of using this as learning lesson for planning future investments.

Is it really a loss to not make expensive equipment operate fully?[6]

In principle, once a piece of equipment is installed in the workplace, regardless of whether it is cheap or expensive, the price is irrelevant to the use of the equipment.

When you must choose between using expensive equipment **A**, or simple equipment **B**, you should choose the one whose overall operating cost is less. (Usually the operating expenses for **A** should be cheaper as the machine is more expensive...) More expensive, higher performing machinery usually has a different problem to consider; that you must put in more effort to technically master using the machine. It is noteworthy here that it is unreasonable to think that "*it is a loss to frequently change setups, because it is expensive equipment*"; there are many other conditions you should consider.

Reducing People Reduces Costs.

Index the *takt*[7] time from the required number and establishing processes where the people can work with 100% capacity[8], a single person could operate multiple machines (or large variety of machines).

If there is the capacity to make more than necessary, it is wrong to think of leaving a machine idle as a loss. It is economically advantageous to set up a standard operating procedure that is centered on the work done by people, while the machine work is considered secondary.

Results of Improvement and Planning

It is not unusual to hear that after implementing improvements, a lot of fork lifts or storage racks and pallets are not used, or space has become vacant. This cannot be valued as an improvement because no matter how many of them you have managed to reduce, the idle ones do not create any profit.

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[6] It is a trap of running expensive equipment to capacity, even if the output is not needed.

[7] "Takt" is a German musical term for beat or rhythm. This is the frequency this is used to synchronize adjacent processes.

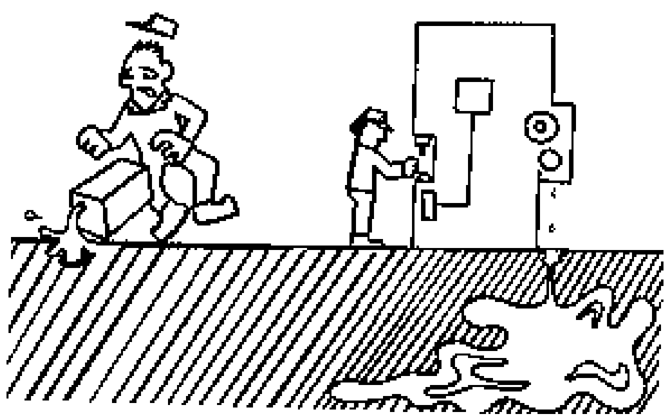
[8] Loading a process to 100% capacity leads to problems like not being able to schedule time for maintenance.

It is important to think about how many unnecessary items looked as if they were necessary depending on your current production method. Give feedback to the planning department so the same type of mistake will not be repeated in the next project. A plan is something that is created based on your current situation.

When there are a lot of unnecessary activities in the way things are currently done, the same inefficient methods end up being incorporated into the next plan. Once the investments are made, they cannot be undone, even if improvements are made. This is important. Such a relationship should be fully recognized. You should make efforts to eliminate the unnecessary activity from sites daily. At the same time, you should not neglect to report unnecessary activity to management once they are brought to light by the improvement process.

Continuous Costs and Temporary Costs [9]

Costs incurred daily seem to be reasonable when you look at them individually, which makes them easy to overlook. On the contrary, temporary expenses tend to be noticed because the often have high costs, so they tend to be viewed as a loss. If you convert the total cost of the continuous daily costs over a year into a single cost, it is often surprisingly expensive. In many cases you feel the costs for the improvement are too expensive (apart from the problem of finding a less expensive way) and the continuous cost is unchecked, leading to loss.



Do not decide things just by feelings, get the facts and always do the necessary calculations. A frequently discussed issue about the installation of signal lights, and cost of setting up sign boards, or, when the improvement increased overtime.

How to use Ratios

Concept such as "***X** ratio is improved*" or " *this approach more advantageous since **X** rate is higher*" may lead different judgment according to its purpose. There are many cases when measures such as the profit ratio of a product or an investment should not be used when

[9] Another example common in factories is air leaks, a cost rarely measured. There are examples where maintenance went around after hours when the factory was quiet and marked the leaks that needed to be fixed. Within a month, the air consumption dropped to less than half (allowing them to shut down a large compressor).

choosing the beneficial product or investment. (The reason is complicated, so it has been omitted).[10]

We would like to discuss the utilization rate in terms of cost. People often think that a decline of the utilization rate is equal to a loss. The most profitable way with least amount of unnecessary activity is to produce only necessary amount of what you need, when you need them. What would happen if we got obsessed over the utilization ratio and have all the machinery working at 100% capacity?

Finished products, as well as intermediate products will be piled up like mountains, and the number of people required could be doubled or even tripled. We will also have to purchase several times the current amount of raw materials and parts than we currently purchase. Looking at this in terms of expenditure and income, expenditure could be three or four times higher, but the income will not change at all. This is far more than just a loss.

It is best to regard the utilization rate as something to be determined by the required number of products. It is important to have the machinery available for use whenever it is needed. If not, this may cause an opportunity loss and overtime which may result in a loss. TPS considers these rates separately. (See Chapter 2, utilization rate and the movable rate)

Summary

In this section, we have discussed how *cost* is considered and how a decision of *economic efficiency* is made within TPS.

Before closing this discussion, it must be noted that the economic efficiency varies in many ways according to external conditions. To put it in an extreme way, what was profitable yesterday, might be a loss today, if any new factors are introduced.

For example, when wage agreement contracts change from time-based to production-based, the problem of profit and loss emerges in a different form.

We believe that there are many other examples, as well as many challenges concerning the necessity of improvement, which have not been discussed in this section.

To sum things up, we have discussed how we should always find out the most economic option while keeping many conditions in mind. Make this the standard way of thinking for implementing improvements.

[10] No further explanation is given in the manual.

Section 3 - Labor Reduction and Quality

About Quality

In this section, we will explain how one should think of quality regarding labor reduction routines, as well as what is the relation between quality assurance activities and labor reduction.

The primary subject is production quality rather than the design quality. Except for special cases, quality is referring to manufacturing quality.

Quality is Built into the Production Process

We are engaged in the automotive industry, and it is our mission to provide a trouble-free car to the customer. To do that, it is necessary to manufacture products that meet the design quality requirements, and this drives the need for quality checks. Conventionally, finished products were checked by a quality inspector, and then sent to the following production process; no matter how much you evaluate the quality of a product that has been already manufactured, this will never lead to manufacturing products of good quality.

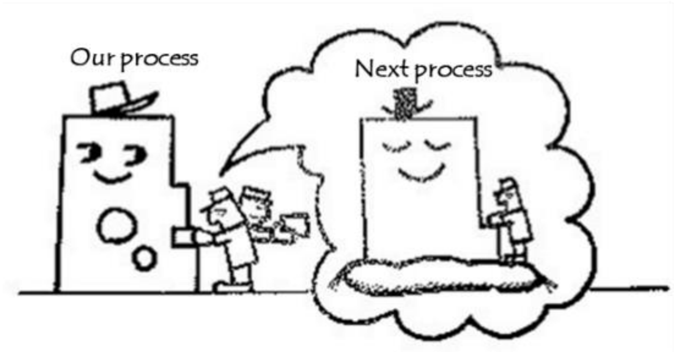
If the quality inspector performs a sampling-inspection and declares the products to be good, but of one them is found to be defective, if we put ourselves in our customers' place, there is no way we would say "*It cannot be helped, it is only one in a thousand*."

All products are subjected to a hundred percent inspection in some form or another. This is where the elimination of dedicated full-time quality inspectors, and the concept of *"build quality in the production process"* was born. Which means completely assuring quality in every single process step where it can only send a good product to the following process. The inspection should be done *inside* the process and defective products removed on the spot.

For the concept of *"building quality into the production process,"* every single person is held responsible. The basic idea is that *"the* following *process is our customer,"* not sending a defective product to the following process is the basis of building quality in the production process.

Despite these efforts, sometimes a defect will be discovered in the following process. If this happens, they immediately contact the preceding process, and the department stops the production process, root cause is investigated, and countermeasures implemented.

The next process is our customer



Without prompt response, defective products will continue to be produced. In addition, it is necessary that the process that produced them must do the rework of defective product. Keeping silent just because it is a minor flaw should never happen.

Letting the following process do the rework without notifying the preceding process is unacceptable. This may result in the production of more defective products. The rework must be done by the department that produced the defective product.

Quality is the True Value of Improvement

To build products of good quality is a priority more than anything else for our manufacturing industry. No matter how many products you produce, if they are of poor quality, then customers will not buy them. Even if you reduce the production costs, if you cannot sell them, there will be a loss.

In the case of automobiles, safety is especially important. We would fail our social responsibility if we bring products to the market where we "*cut corners*" or made the excuse of *"we had our hands full"*, or *"we made it cost less".* This can turn out to be fatal for a company.

In short, ensuring the quality is the first thing that must be considered. You are giving priority to a less important thing when you make little of it for some other reasons. Consider what kind of work does the term "*quality assurance work*" refers to.

Unlike in the past, when the intuition of the operator or the degree of skill played greater role, today each process is segmented, and less specialization of skills are needed. Standard work for each production process is part of quality assurance.

Standard work must be designed to ensure the required quality. If there is unevenness among the processes, checking process by visual observation or gauge must be incorporated into standard work as a single process.

If defects are still produced under these conditions, then it is either because the standard work is not followed, or because there is some defect in machinery, equipment, molds, or tools. Understand why people are not following standard work.

Sometimes people say things like, "*When we tried reducing labor, defects increased*" or "*We reduced too many people, which shows up in our product quality*."

As we explained earlier, looking at it from the concept of the TPS, this is putting the *cart before the horse*, and it should never happen.

By looking at what kind of issues take place, they can be broadly divided into the two categories:

(A) Omitting or forgetting some of the necessary procedures, under the impression that the work that must be completed in a shorter time. Rather than eliminating unnecessary activity, they end up cutting corners instead.

(B) Since we previously had surplus of time allotted; creating intermediate stock and rework were possible. The labor reductions have exposed our quality defects.

The case of (A) is commonly encountered in assembly work done on conveyor lines. This mistake occurs because the line was not stopped to avoid delaying the production process.

In the labor reduction activities, people are well taught about the importance of stopping the line. The first thing to teach a new person is how to stop the line.

By stopping the line, we can find out about the imbalance between the amount of work assigned to each person and discover facts for the elimination of unnecessary activity. It is also possible to solve the fundamental cause of the delay.

If people omit some work because there is not sufficient time allotted, it may be because they think the line must never be stopped. The supervisor is responsible to make sure that people understand that passing a complete product to the following process is more important, even if it requires stopping the line.

There is no need to obsess over line speed or *Takt* time. It is important to clarify that "*Takt time and the number of people are unrelated*." The person is doing all that is required at their own pace, so a cycle of work is completed.

If they do not finish within the Takt time, the line may be stopped until it is completed. Making sure that work fits within the takt time requires completely different measures, and that is the job of managers, supervisors, and technicians.

For instance, if a person requires 70 seconds to finish from process one to process five, while takt is 60 seconds, they would exceed takt by 10 seconds. There should be no need to explain that we must never omit those 10 seconds. The people should do their work normally, and the line should stop for 10 second intervals every time to make products with good quality.

It is the job of the supervisors and the technicians to implement improvements to make sure that any person can finish the processes within 60 seconds working at a normal pace. By cutting down unnecessary activities or reducing the distance they walk, with improvement, there would be no need to stop (delay) the line.

If you try to eliminate the line stop without improving the working process, this will naturally result in a lower quality of products; this must be strictly avoided.

In the case B, by reducing the number of people and inventory, we see that many defectives were produced frequently. These were reworked within the production process rather than solving the root cause.

A following process fixes the defect caused by a preceding process without giving feedback. For example, there is a mismatch with the tapped hole due to a design problem. You fix it with the correct screw holes in your process.

Because the problem is managed, the root cause remains unsolved. The additional labor and inventory for these makeshift repairs increase the cost. When these problems are made obvious because of labor reduction process, it is a chance to improve.

Supervisors and technicians must return the defective products to their respective departments. They should visit the preceding process to pursue the root causes behind these defects and solve them starting with understanding the root cause.

This can be compared to taking pain medication for chronic appendicitis, instead you decide to get surgery and fully recover.

This concept also applies to solving the defects caused by machines, equipment, molds, and jigs, which we have described earlier. If we find that the equipment is causing a defect, it is important that we stop the line immediately to identify and eliminate the root cause.

If we end up doing in-process readjustments on our own just because the maintenance department would not respond after we contact them, we may start to fix the problem within our own production process, and this imperceptibly becomes a part of the regular process.

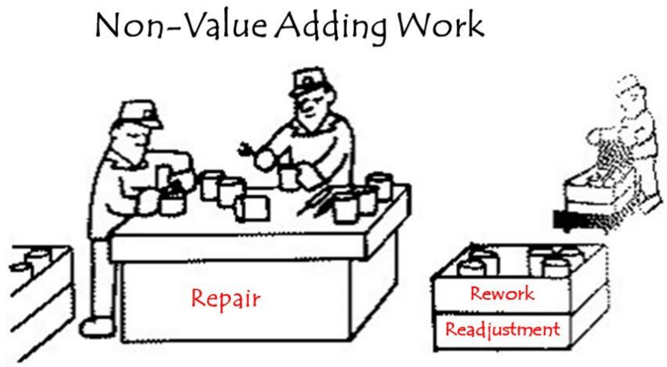
We should not stop with a single written request or a single phone call. We must keep taking measures patiently until we get a product of perfect quality.

Defects and Inspection

Think about why sending out a defective product is unacceptable. If the assembly line which is the final process of production, sends out defective products, then it is highly possibility that a defective product might reach the customer.

This is unacceptable, because this affects the trustworthiness of the company and the credibility of the product, more than anything else. Normally, defects are discovered by inspection and reworked before they are sold to the customer. The more the company is determined not to put a defective product on the market, the stricter their inspection becomes, and thus the more frequent rework needed. This only increases your cost.

The extra inspections done is work that does not result in any value being added to the product. Manufacturing can build gauges into their jigs and fixtures an automatic inspection process that reduces the possibility defective products being used (this is called *poka-yoke*). This is done to ensure that every single product is of good quality.



We believe that the readjustment should be regarded as work that should not have existed from the beginning. The more people you need for inspection and rework outside of the process, the lower value-added ratio in the plant becomes, and the more the costs will increase.

You cannot say, "*This product is expensive because we test it 10 times*". This will not be accepted in the market. Work that does not add value is just an *unnecessary activity*. It is something that should be eliminated from the beginning.

Even if you omit the unnecessary activity within the direct work process and achieve some labor reduction, if you produce defective products, then inspection and rework increase the labor requirements. If you consider this from the point of view of cost reduction, the result may come out even, or even a loss; this result is far from the original purpose.

For this reason, we think in the following manner:

The inspections outside the process as well as rework are both unnecessary activity. We want to eliminate them as much as possible. Inspection should be the minimum necessary and no rework required (you inevitably reduce labor).

It is important to be aware that large labor reductions are possible by eliminating inspection and rework operations, as you strive for improvements.

The in-process inspection should be considered as follows:

It is necessary for the people to check the quality of products they made, namely the 100% in-process inspection. We regard the following production process as the customer, so not a single bad product should be released.

It is important to be creative with all the various aspects of inspection methods. In addition to visual inspection or gauge inspection, "*Poka-yoke*" (error-proofing) must also be considered.

As for lot production such as that using high-speed autonomated presses, we accumulate say 50 or 100 pieces over the chute and inspect the first and last piece. If they are both good, they go ahead and get transferred to the pallets. If there is a defect with the last piece, examine from which piece the failure began to occur, get rid of them. Then you must take measures to prevent such defects from happening in the future.

This is a type of total inspection. Even in a fast, quick production process, you should not think that you can conduct only sampling inspections. It is important to build in the quality within the production process.

The Goal of the Inspector

Consider the concept of "*inspections performed by an inspector*." The job of an inspector is the determination of whether a product is defective. They sometimes think that is enough to just pass the results back to the previous step.

This is not enough. The inspector should be responsible for doing workplace analysis of why the failure occurred, and as much as possible, for determining the cause, and stop the reoccurrence of this problem.

They should not merely be an inspector who performs a of pass or fail test. The inspector must be a teacher who explains what was wrong and teach you so as not to repeat the same mistake.

For example, if a matter that came up was a mistake during parts assembly, the cause might not be just as simple as "*I was careless*". There might have been many various causes. For example: the parts were not lined up in their assembly order, the line stop button, or the call button was too far away, or the work instruction information was difficult to read.

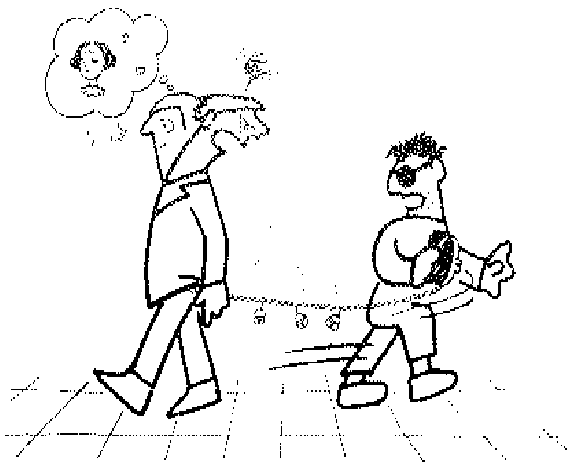
Without identifying these causes and taking the appropriate action, failures will not be reduced. The purpose of the inspector's work is not to toss out the defective product but to *reduce them to zero*. Their work is evaluated on fulfilling this task.

Poka-Yoke (error-proofing)

To build in high quality in a production process, we must think about which points the people need to check, which places do they have to measure, or when do need to replace cutting tools.

Devise ways of using jigs and fixtures so that products sent from the previous step are checked spontaneously. This means that you incorporate *poka-yoke* (error-proofing) within the production process to discover defects.

It is important to standardize *poka-yoke* to make sure that even if people are changed, stable quality is produced.



Even the most careful people sometimes can make inadvertently mistakes, especially when they measure while performing other tasks, or doing the check by following a checklist.

That is why it is important to devise a mechanism that spontaneously eliminates defective products, operational errors, injuries or any other problems, even without a person paying attention to everything. The automatic discovery of any shortcomings is "*poka-yoke*."

To explain the mechanism of "*poka-yoke*" a little more specifically,

(A) A mechanism where products cannot be mounted in jigs when there is an operational error.
(B) A mechanism where the machine will not start when there is a problem with the product.
(C) A mechanism where the machine will not start when there is an operational error.
(D) A mechanism to automatically correct operational errors before proceeding with production.
(E) A mechanism to detect problems made in the preceding process.
(F) If some work is left incomplete, the following process will not start.

Mechanisms other than these can also be considered. The following can be thought of as *poka-yoke* methods.

1. Signs... visualize the fault with lamps and color coding to make it easier to be discovered.
2. Jigs... devise a jig so that it will not accept different products, or it does not operate when there is a mounting mistake, etc.
3. Autonomation... to stop the machine when a problem happens during manufacturing. This is sometimes not counted as "*poka-yoke*."

Poka-yoke is an extremely important part of building in quality during the production processes. The aim is reducing problems to zero. To achieve this aim, it is important to think of methods like those mentioned above, and to find the places that are easiest to grasp, as well as those with minimum loss, when establishing "*poka-yoke*."

Section 4 - Labor Reduction and Safety

Safety First

There is a saying, "*There is no use crying over spilt milk*."

Various assets such as machines, even if damaged, can be restored by spending money, but human body is less likely to become fully recovered once injured. A fatal disaster, such as accident causing death, cannot be compensated with money.

Safety must be considered before everything else. There is no labor reduction where safety is not considered. We must consider safety as a foundation, then think of all possible ways for labor reduction within that scope to reduce cost.

Sometimes we see cases where the improvement routine is not allowed to proceed in the name of safety. At such times we need to go back to the starting point and review the purpose of the work.

There would be no development or progress, if you think, "*let sleeping dogs lie*."

Relationship between Labor Reduction and Safety

You will see that the seemingly conflicting values of safety and labor reduction are consistent with each other, because the labor reduction means also promoting the elimination of unnecessary, uneven, and unreasonable activities.

Most of the accidents in production plants occur because of behaviors that can be thought of as activities that are unnecessary, uneven, or unreasonable.

We believe that doing or being made to do things that are unnecessary or things that are hard to do, leads to unnecessary activity, uneven, and overburdening actions which end up in injury.

We could use the Japanese characters for the word "*Injury*" to write "*This is odd if I do say so myself*". *Odd* behavior that includes unnecessary activity, unevenness, and overburden is the cause of injuries; eliminating unnecessary activity, unevenness, and unreasonable things leads to safety.

Workplaces where accidents are frequent, the day-to-day management is insufficient. These accidents occur frequently where the basic matters like 4-S[11], working procedures, and job instruction are not considered or even unrecognizable.

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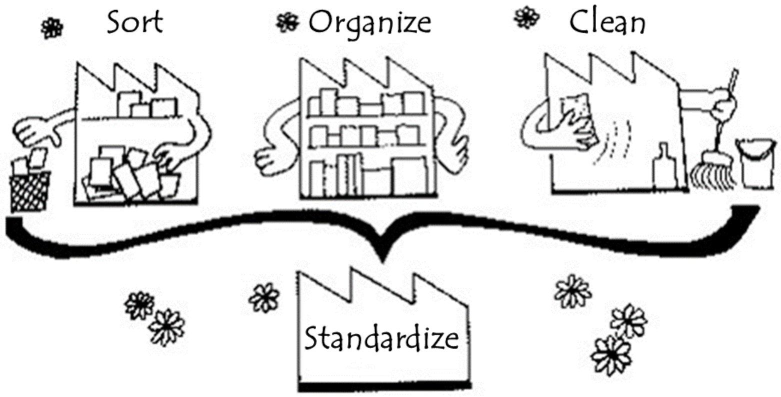
[11] 4-S is taken from four Japanese words that start with 'S' – Seri, Seiton, Seisou, and Seiketsu. Later consultants have added others to become 5-S or 6-S, complicating the original program until the tool becomes an independent program, without understanding why it was useful in the first place.



Workplaces that are passionate about their labor reduction and improvement routines, have fewer accidents. The more simplified the workplace is, the easier it is to manage. We emphasize *4-S* as an aspect of safety management. *4-S* is based on the people, materials, and equipment as they currently exist.

If the layout of the machinery and equipment is poorly designed; then practicing *4-S* will not achieve its purpose.

There is a limit to how much you can sort something when it is moving towards complexity. It should not be overlooked that people, materials, and equipment in the workplace are not independent from each other but rather connected in a complex manner.

For example, this vicious cycle: there are too many people → too many products (accumulate stock) → more people needed for clean ups, loading and unloading, storage or rework is required → even more people.

Increasing one thing increases other things in the workplace, complexity is in direct proportion. It is important in advancing the safety management to hold off this tendency for complication as much as possible by labor reduction.

We will briefly explain *4-S*; it refers to sorting, organizing, cleaning, and standardizing.

(A) Sorting (***S****eiri*)

To divide things into needed and unneeded and dispose of the unneeded things immediately.

(B) Organizing (***S****eiton*)

Arranging needed things in an easy-to-use manner.

(C) Cleaning (***S****eisou*)

To clean up and keep things tidy.

(D) Standardize (***S****eiketsu*)

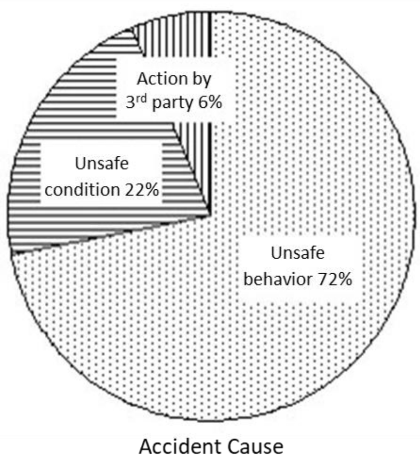
To maintain the state of (A), (B), and (C).

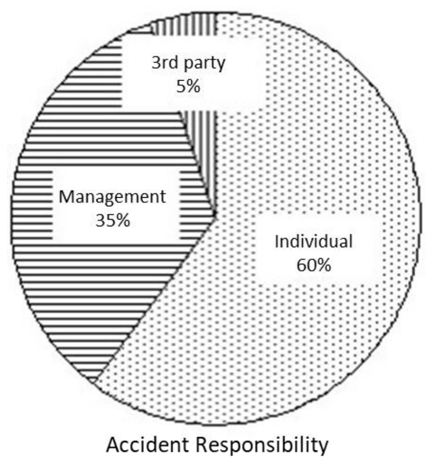
The status of accidents in our company

Looking at our company's accident status, we find that there were more than 800 occurrences of accidents per year. These accidents can be considered as just the tip of the iceberg.

There may be even more workplaces which are in similar conditions to ones where accidents took place, as well as ones that are continuously exposed to danger even though accidents fortunately have not occurred?

Two years ago (1970), 878 accidents took place. If we consider Heinrich's law[12], there are probably an even larger number of people who experienced near-accident situations, even if it did not end in one. Such dangerous situations cannot be left unimproved.





Analysis of the main causes of accidents, as well as the risk conditions of the cause itself, we find that there were 142 incidents where safety was not taken into consideration; 77 incidents where maintenance adjustments were not being made, and 14 incidents where there was no safety switch. These indicate that there is much room left for improvement.

If you look at the accident report, it shows many management responsible injuries linked to machine problems (20%); and the most frequent factor of accidents were forgetting to turn off the machine before working on a problem is (30%).

We have a problem in our current way of preventing recurrence of equipment issues, and in our accident preventive maintenance systems.

One problem behind all of this; equipment issues are all left for the production workplace to handle. It is necessary to address the problems not only within the workplace but also with management.

[12] Heinrich's Law - In his 1931 book "*Industrial Accident Prevention, A Scientific Approach*", Herbert W. Heinrich put forward the following concept that became known as Heinrich's Law: in a workplace, for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injuries.

The pie charts show the number of accidents grouped by main factors and the responsible party. At 72%, "*unsafe behavior*" is the major factor for accident cause. Individual behavior is the dominant factor when we look at responsibility.

Within a simplified workflow, there are almost no unnecessary, uneven, or unreasonable movements, thus it becomes easier to perform. It is also easier to manage. In this sense, the more simplified the work becomes, the less risky behavior there will be.

This gives birth to the necessity of "*visual management*" for leaders. They need to be able to immediately recognize when people do unsafe, unstable actions. This is how simplification is connected to the safety aspect in labor reduction routines.

First step towards a safe production site

Safe work environment requires a company-wide deployment. The first step is to create a workplace that is free from unnecessary, uneven, and unreasonable activities. We need to create an environment where it is easy to discover these unnecessary, uneven, and unreasonable activities.

(A) Under what conditions will work be carried out?

(B) What kind of procedures will be performed?

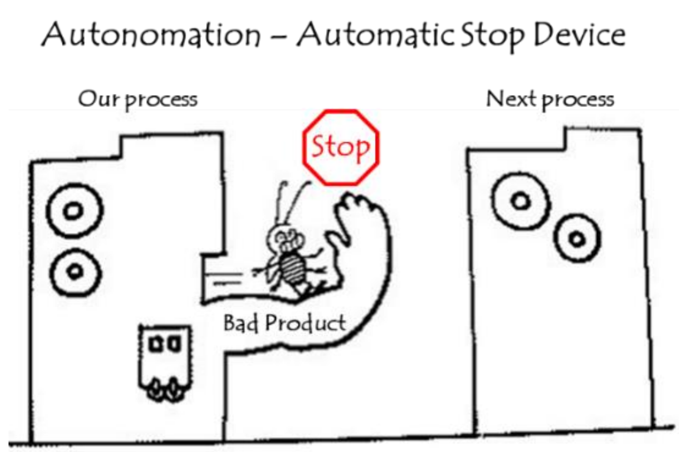
(C) What length of time for performing activity?

A job instruction manual that specifies A, B, and C, should be defined (and maintained). Following effective job instructions will lead to creating a safe production site.

Our conclusion is promoting labor reduction will also lead to safety. To create a safe workplace, we should continue to expand our labor reduction activities. Following this, we would like to consider the issues of autonomation (*Jidoka*) and one-touch activation.

Simplistic Automation Causes Injury

Along with the increase of production in the past few years, the automation in our company has been rapidly developed. For the most part, the necessity of such automation has not been sufficiently questioned (i.e. there has been no thorough investigation regarding its unnecessary, unevenness, and overburden activities) thus, breakdowns occur often. To make it worse, there are high-speed machines without an automatic stop device, so it is extremely dangerous.



Because the automation was not designed as *Jidoka* (i.e. it was designed for *labor-saving*, rather than *people saving*), we still need to have someone to act as a guard, otherwise, it would come with the risk of the machine not functioning as required. "*Autonomation*" means that a machine is equipped with a safety switch, which stops the machine when an abnormality occurs. This is important both from the safety perspective and from the labor reduction.

A machine that cannot automatically stop itself in the case of an abnormality, is at risk to bring about unexpected accidents.

The more expensive the automated equipment is, the more we worry about it getting damaged, which ends up in our assigning people to guard it. The people who guard it are rarely its designers, or its makers, and are not even the ones who do its maintenance, this rather increases the risk of an accidents.

For example, consider the following:

> Near an automated conveyor, we often see a sign that says: "*Turn off the switch before climbing onto the conveyor*."
>
> At first glance, it calls attention to the safely and looks as if the safety is assured; but above the conveyor, there is a platform on which there are often bars for moving anything stuck in the conveyor.
>
> A person may not want to climb on it, but if the need were to arise, they might turn off the switch before climbing.
>
> When the conveyor cannot be fixed immediately (maintenance thinks it can wait, it is good enough if it just runs at 80%). And there is an expectation from management to ensure the production targets are met. Would the person still follow the rules and turn off the switch before climbing up on the conveyor?
>
> If an accident occurs, this will be reported that the **person** did not follow the rules. And the excuse might be given that the person did not receive enough training. But the real reason is the presence of incompletely automated equipment that it was left as it is.

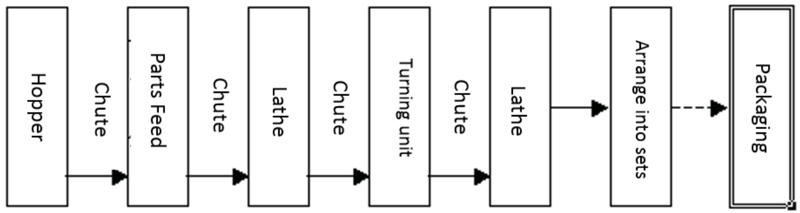
For truly automated, self-activated equipment, must be structured such that running at 100% functionality is considered as a given, otherwise it must have the structure that stops automatically in abnormal situations.

The 20% of the conveyor stops that were recognized as acceptable, should be considered as the cause that leads to injuries.

Example from a Machine Factory

Review the facts of a case that took place in a machine factory. Cases like this are common in automated work sites.

In the processes shown in the diagram, a person had their finger severed by a lathe. Originally, the person's job was just to take the work that was automatically arranged into sets and pack it into boxes. Since there were about 10 lines like the one shown in the above illustration, a single person should have been enough to cover them. However, there were always three to four people on each line to improve the flow, otherwise scheduled production could not be met.



Because the flow through the chutes were irregular and the "*No Work*," "*Pass Confirmed*," and "*Full-Work*" switches were not properly maintained, when an abnormality took place, the machine would not stop.

The accident occurred when the person's finger got stuck in a machine that was running "*automatically*."

For this example, a person observing that workplace should question why one person could not do the job. Improving the flow on the chutes would achieve real labor reduction as well as creating a safer work site; and more importantly, an accident could have been prevented.

Is *'One-touch'* activation a risk?

We have explained that the concept of labor reduction and the direction we are headed for do not go against safety, but rather, they coincide with the development of the various conditions required to promote safety.

At the end of this section, we would like to mention an example of a stamping press where labor reduction also resulted in safety improvement.

One-touch activation for machines such as stamping presses has begun to be adopted. In the machine shop, it has been utilized for quite a while. This is because of the concept that multi-machine handling is a matter of fact and has brought out many innovations which consider safety.

If we go with a conventional type of activation that uses a two-hand "*hold-to-run*" button until the press reaches the bottom dead center, that waiting time would be an unnecessary activity, and the extra waiting time kills the benefits of multi-stage machine handling.

Why have the two-hand "*hold-to-run*" buttons been utilized up till now? They have been adopted to meet Labor Safety Regulations. According to the Labor Safety Regulations, "*Machines such as presses must include measures to prevent entrance of body parts in the* *danger zone when using slides or cutters. This does not apply to presses structured so that the slides or cutters can be immediately stopped when a body part enters the danger zone*."

The two-hand "*hold-to-run*" system merely complies with the latter part of this paragraph, but it does not fulfill the original purpose. Even if it has a two-hand "*hold-to-run*" button, if a third person is involved, then it does not work effectively unless the person who did the activation noticed the danger.

The problem is not whether one-touch activation is bad, but is the machine structured so that it can make an emergency stop when a body part is detected in the danger zone.

Progress in the development of devices such as activation buttons with safety structures, where the machine immediately stops if something approaches it, reduces the risk associated with activation using a one-touch system. The machine must be stopped in the event of a fault of the safety device.

Even better would be a machine that people can use without putting their body parts near any danger zone. Such concepts have been gradually getting introduced in stamping presses and automatic welding lines.

For example, there is a 250-ton press that is equipped with the copper wire at the lower bottom of the shutter. If something touches the wire, the limit switch will stop the press.

There is a new type of automatic welding machine with a platform around it. It will not operate while a person is standing on the platform.

Both are examples where a push button was converted into a one-touch operation. These are still elementary devices, with further improvement, we will probably be able to make all activation buttons into one-touch.

Even if you stop thinking about the rationalization of the work, convinced that there is no choice for the sake of safety, you may notice that there are several options of a safe and rational way of working, just by going back to the fundamental purpose of the work.

Continuous effort put into coming up with working methods, and systems for equipment or devices that lie within the margins of safety, while choosing the ones with the minimum unnecessary activity, will surely become even more important in the future.

Section 5 - Labor Reduction and Human Relations

Respect for People as a Foundation of TPS

Labor reduction is often considered as speeding up of labor; but the Toyota labor reduction activities aims mainly the elimination of *unnecessary activity*, and it does not mean labor intensification or speeding up.

For example, a person must walk five or six steps to pick a part for the assembly line, or they are going back and forth many times to the car. By directing those five or six steps, and the effort of going to and from the car, into work that clearly results in added value, we will be relatively reducing labor.

Like this example, everyone believes the work they are doing as part of the task, yet there are many unnecessary activities that do not add any profit. The idea is to eliminate these unnecessary activities (behaviors); shifting a person's energy to more useful work leads to respect for human dignity.

There is nothing more demoralizing for people who are offering their precious energy and time to the company and are forced to waste it. Concentrating their efforts into work that is useful is the beginning of *respect for people*.

Human beings are motivated when they focus on meaningful work and are recognized for the value of their own work. On the contrary, when they are forced to do meaningless work, consciousness of their work value becomes totally out of question. And of course, we cannot expect them to be motivated (good morale).

There is a limit to the energy that can be produced by a human. The extent that you have been able to redirect this effort into useful work is linked to respect for people.

If a problem arises with labor reduction being labor intensification, or ignoring humanity, then there was something wrong with the way of reduction, or it is because of some misunderstanding.

Thinking from other people's point of view to build true relationships

When conducting labor reduction activities at the workplace, if they put themselves in the shoes of the people doing the work, then true human relations will be developed. There should be few problems like complaints of labor intensification surfacing.

If they stand in the workplace every morning to observe how they do their work and think from the people's point of view to achieve improvements, making a full commitment till the improvement will finally works, then the supervisor will not be isolated from the people in the workplace. We cannot build true human relations by mere superficial praise or flattery.

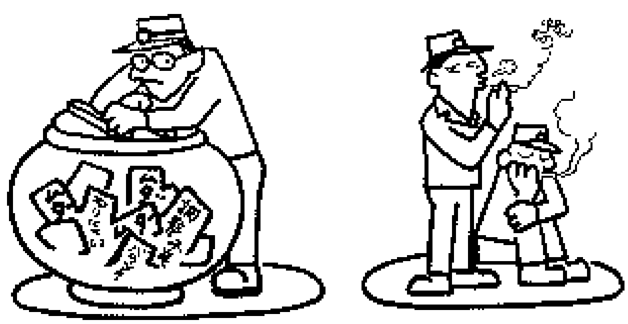
There is a story about Hirobumi Omatsu, a famous coach of the Japanese volleyball team. It is an old story, but I think it helps understanding the development of human relations in a company, so I quote the example below.

> Coach Omatsu, never flattered or coaxed the team to encourage or motivate them. Instead, he thought from the player's viewpoint. By doing so, he established a relationship of mutual trust with the team. His rigorous training was based on mutual trust. In the game, he would make the best use of players and the players did their best to meet the expectation of the coach.

For a supervisor to have the workplace following their instructions, a relationship of mutual trust must be built between the supervisor and the operators, there must be true human relations.

To achieve this, the supervisor must have *respect for people* as a foundation, while constantly putting themselves in the people's shoes. They must train them while fully understanding them, stand in the lead, and proactively confront all problems, no matter how troublesome they might be. What is especially important here is the fact that when there is any kind of problem in the workplace, someone is troubled by it.

For example, "*The work is hard*," "*This is dangerous*," "*It is difficult to adjust, producing too many defectives despite our hard work*," "*The demand from the following process is so variable that we cannot decide on our priority order*," "*The Standard Work sheet is difficult to read and understand*," and so on.



Everyone complains these kinds of issues at the beginning; if a prompt response is not taken, then people gradually cease to complain, and the problem left unsolved.[13] If you ignore these issues and just keep saying "*Reduce people!*" or "*Do improvements!*", it can only lead to growing discontent and complaints.

If a supervisor puts off work they must do and just pushes it onto the operators, it is only natural for the people, as human beings, to feel distrust towards them.

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[13] This is a source for many of '*people problems*', like bad attitudes, especially towards managers. The leader has left the problem unresolved which makes for an unpleasant workplace.

A collaborative attitude of supervisors and staff to share the difficulty and hardship of people at the workplace, to think from their perspective, to solve problems together, will establish their trust in the supervisor. Which cultivates working together for improvements.

By following the concept of "*people must be treated as individuals (as human beings),*" which is mentioned in TWI's "*Job Relations*" (JR) as a foundation, it is important to take care of various issues of human relationships to make full use of the people's capability and abilities.

This spirit is the essence of human relationships, which has not changed and will remain unchanged. Aren't we partially lacking in the senses of unity and trust, which arise from the experience of sharing the meals, struggles, and joys together. In the workplace, it is important to revive the sense of solidarity. The labor reduction activities must be deployed from that solidarity. It is important to let people participate in the activities so that they can share their opinions with us and come up with ideas together.

The concept of labor reduction itself is reasonable and convincing to everyone. If the reasons are misunderstood and are a hurdle for relations, it is often that the mutual trust has already faded. And the people do not have the mindset to try to understand the aim of the supervisor.

As an example, here is a case where they improved the factory's final assembly line.

(A) A brief explanation of the situation:

1. Late September 1946: the Takt was increased from 16.6 vehicles per hour to 18.2 vehicles per hour (without increasing the number of operators).
2. Through the end of September to late October: 120 - 150 minutes of line stops occurred per shift.
3. Many complaints from the operators were reported to the labor union such as: *"Too much work," "This is labor intensification*."
4. Mid-October: together with the technicians from the service department, we went to the production lines.
5. We applied improvements centered around the problems that people have difficulties with on the line.
6. The number of line stops during the mid-November have been reduced to 20–30 minutes per shift.
7. Approximately 100 improvement activities, large and small, were carried out. Only the first 20% of the improvement were carried out by the supervisor, the remaining 80% were applied by the people at the workplace.

(B) The reaction in the workplace:

1. The complaints, which were reported from early September to late October, are no longer reported at all.
2. Many ideas for improvement were proposed by the operators in the workplace and are getting implemented one after another.
3. In the evaluation meetings of team leaders and supervisors held in November and December, the following opinions were given:
    a. The people in the workplace became more motivated. They developed positive attitudes.
    b. There is still some unnecessary activity that needs to be improved.
    c. Team leaders need more time to spare so that they can sufficiently focus on improvement.
    d. It was very good that their requests have been immediately responded to. From now on, we would like the technical service department to fix problems at the workplace immediately. They should not leave problems unsolved.
4. In just in one month, the motivation of the workplace has been raised a lot. Complaints about "*labor intensification*"[14] completely disappeared.
5. Recently, this is how the workplace feels:
    a. Whenever they spot the improvement staff, they come and discuss immediately whatever problems they are facing.
    b. Suggestions for improvements are proposed by operators: "*It would be better if we do this*."
    c. In implementing the improvements at the workplace, the operators decide the arrangements on their own, and carry out it together after regular work.

Mutual trust starts with participation in improvement activities

Supervisors and staff must respect the proposals and discussions coming from the workplace and collaborate with operators to promote labor reduction activities.

All people involved can enhance their motivation towards improvement and have a sense of participation in the improvements. Reducing the feeling of dehumanization that comes from the monotony of the work.

[14] Speeding up of work, making work harder.

From the operator’s point of view, they realize that they can improve their workplace by themselves and feel the sense of achievement and satisfaction that they accomplished the improvement of their own. This will enhance their confidence, encouraging them to find further possibilities of improvements.

The sense of achievement, sense of satisfaction, and self-confidence are keys to overcoming the feeling of dehumanization. This is a source of motivation and eagerness that “*we can do it*.” In a workplace with this kind of awareness, you can expect natural rise of morale.

An example: When the production of a machine factory needed to be increased, the front supervisor gradually increased the speed of the assembly line conveyor, while the rear supervisor consulted everyone about what to do.

In this example, the front supervisor made remarkable increase of production in the beginning but were stuck after a certain point. The rear supervisor that took some time before implementing the improvements achieved a final faster production rate.

Supervisors and staff should always try to promote the improvement activities together with the people who work there and spare no effort to create an environment and atmosphere in which everyone can participate in the activities.

Signals are used in every plant to create the conditions that enable visual management. They make it easier for everyone working at the place to find the problems and improvement points will be easy to discover. To enhance the desire of everyone to participate, we actively work to include all the people in labor reduction activities.

In our plants, with the supervisor at the center of the workplace, people propose constructive ideas to each other, such as: “*This process will be better done by this way*” or “*There will be less unnecessary activity by doing this process in this way rather than that*.”

This eagerness to pursue their aim to reach satisfaction and fulfillment, their morale is the evidence of the smooth human relationships in the workplace. It is an embodiment and manifestation of our founding spirit.

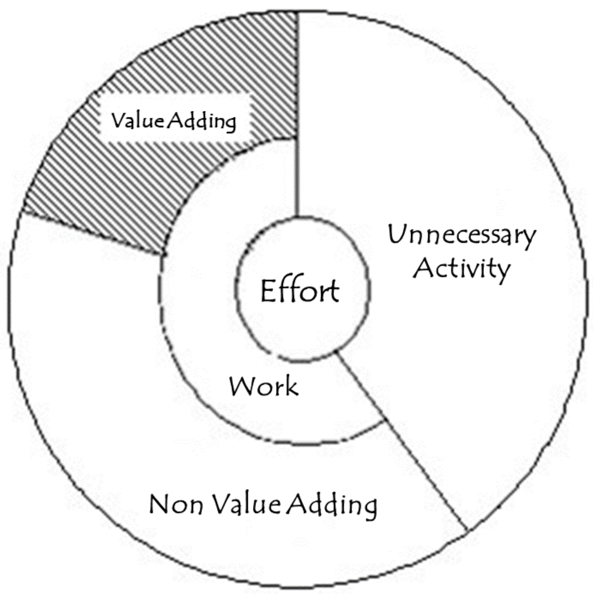
Section 6 - How to Promote Labor Reduction Activities

Awareness of the details of the work in the actual workplace

To promote labor reduction activities, developing awareness in the workplace is an important first step.

For example, if you think, "*The line utilization rate is fairly high under the current operation system. The manufacturing failure rate is within certain range. All in all, it looks like working quite good*," then, there will be no motivation for improvement. You are nipping off the buds of improvements.

No matter what kind of workplace it is, when observed closely, what is said to be "*work*" can be divided as shown in this diagram.



The types of work are:

A. **Unnecessary activity –** It is not necessary in any way when doing work. They can be eliminated immediately.
(Examples) Waiting time, meaningless transportation (piling up of partially-finished products, the labor of transporting two or more times, or changing hands.)

B. **Work that produces no added value -** Work with no value-added is something that <u>must be done</u> under the current working conditions. (It is better to consider this to be unnecessary activity as well.) To eliminate this, we must partially change the conditions of the workplace.

(Examples) Walking to pick up parts, unwrapping the outsourced parts, taking out parts from a large pallet in small amounts, or operating hold-to-run buttons.

C. **Useful work that adds value**.

Apart from regular work, things that are done as exceptional operations outside of standard work, like fixing a small problem that happened to the equipment or jigs or readjusting defective products and so on, reduce the value adding ratio.

The proportion of activities that directly increase the added value is surprisingly low. (All elements, except for value adding work, only increase the cost).

Labor reduction means increasing the ratio of the *value-added work* (profitable work). Our ideal goal is to get as close as possible to 100% *value-added work.*

Unnecessary activity of over-production

In the previous section we discussed that if we closely observed the work in the actual workplace, we will find that it includes many other activities than *Value Adding* work. If these unprofitable activities are clearly visible to everyone, it will not be difficult to study measures to improve the situation.

For instance, within the work done by a group of people, everyone spends some time waiting, or doing meaningless temporary movement of items. In a production line, if we eliminate the unnecessary activity and redistribute the work activity, reducing the number of people will not be that difficult.

This is rarely the case that there are no unnecessary activities; rather the unnecessary activities are hidden and invisible. The most common issue on sites is the excessive advancement of work. Because operators work on the next unit during the time that should be counted as waiting time, the unnecessary activity of waiting becomes invisible. This process repeated over and over again ending up with stocks piled up in the middle and end of the lines.

To make matters worse, additional tasks arising from the over-production, such as moving these stocks to other places or re-stacking them neatly make it even more difficult to distinguish the unnecessary activity.

In TPS this is called unnecessary activity of overproduction, and among the numerous types of unnecessary activity, we regard this one to be the one that must be avoided the most.

The classification and explanation of the types of unnecessary activity are described in detail in Chapter 2, we will omit it here; the unnecessary activity of overproduction is different from the other types of unnecessary activity, in the sense it hides other types of unnecessary activities.

From the viewpoint of improvement, the other types of unnecessary activities give us clues, while the unnecessary activity of overproduction conceals them, and works in the direction of obstructing improvement.

The first step to promote labor reduction activities is to eliminate the unnecessary activity of overproduction. For this purpose, the line should be improved by establishing rules that prevent overproduction and by imposing restrictions with the equipment (such as a full work equipment). Only when you accomplish this, will the flow of things return to its original form.

As things that you need began to be produced individually, as they are needed, unnecessary waiting time becomes visible and noticeable. Once the production line reaches such a state, it will be easy to apply the routines mentioned at the beginning of this subsection: eliminate unnecessary activity → redistribute work operations → decrease the number of people.

The Concept of Takt [15]

To avoid overproduction and produce only what is needed, when it is needed, it is necessary to know the time "*when*" it is needed.

The concept of "*takt*" is important. Takt is the amount of time that should be allotted to produce one product. For instance, the product must be made in X minutes and Y seconds. This is derived from the required number of products.

In a simple formula, it would look like this:

$$\text{Takt Time} = \frac{\text{Operating time available per day}}{\text{Required number of products per day}}$$

A common error in calculating takt happens when you use current equipment capacity, facility capacity or available labor.

For instance, "*Our equipment has this much capacity, and we have this many people, so how many minutes would it take us to produce a single item?*" This is what they consider their Takt time to be. This is a completely wrong understanding of the concept of takt in TPS.

There is less flexibility in the equipment capacity as they are fixed to some extent, but, line capacity may be increased or decreased by adjusting the number of people.

[15] Takt is a German musical term for beat. Here we use it to pace the required production rate.

Work can be carried out by the minimum number of operators only when the takt is calculated based on the correct understanding of it.

If you try to produce as many products as possible at the maximum capacity under ideal conditions, you will end up with overstock and this will not lead to any labor reductions.

When you have determined the appropriate takt, what should you do so that it is accurately followed? Details will be explained in another section.

Follow these guidelines:

- **(A)** In the case of line work: draw a separator line on the conveyor to mark a section designated to one product. The conveyor should flow keeping to the regulations: one product in one section.
- **(B)** In between the processes: employ visual signaling methods. For instance, place a sign or tag (*Kanban*) and make it a rule not to be allowed to conduct the work before the tag (*Kanban*) is taken off.

For more details on *Kanban*, see Chapter 4.

The role of *Kanban*[16] is in the process to prevent overproduction by communicating the required needs to the preceding process. This should be well understood.

Redistribution of Work

By limiting the ability to overproduce, the unnecessary activity of waiting will become visible in the workplace.

Next, work that does not directly produce added value as defined in Section 1 (requires awareness of the details of the work done in the actual workplace) should be improved immediately, starting with those that do not cost much money and do not affect the preceding production process.

For example, when people need to walk to pick up parts, we should move the shelves that contain the parts and eliminate the walking time. After adjusting the line like this, we redistribute the work of all the people.

When distributing work within the takt time, only assign value adding work and the work that cannot be currently eliminated.

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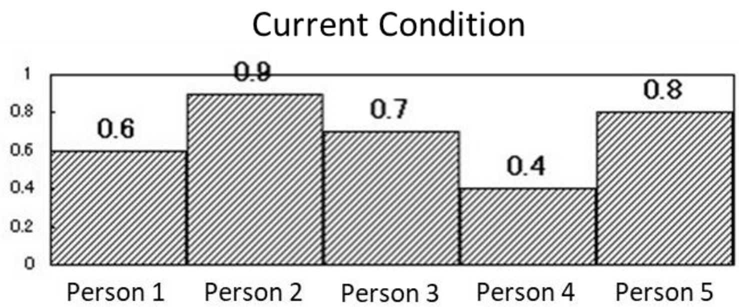
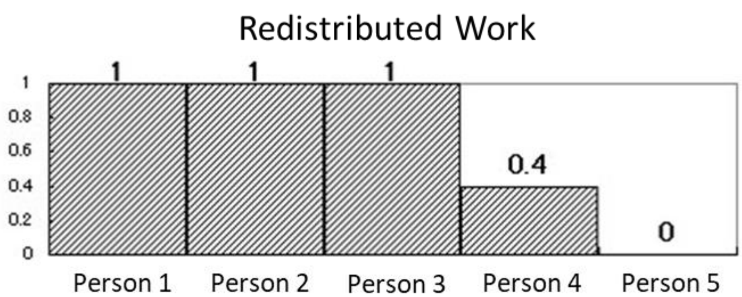
[16] The kanban card is a demand signal to the preceding process that materials have been consumed and need to be replenished. The Kanban System was developed to control inventory visibly as would happen on a dedicated conveyor system. With a conveyor, you can visually see when you need to add materials to the feed and it limits how much you can add. Kanbans should not be used between activities that have visual contact.

If we simply explain this using a diagram:



The current work distribution becomes;



It is important to note that *the surplus time of person 4 must not be equally redistributed*.

The equal redistribution of the surplus time obscures the unnecessary activity of waiting that had been clarified and made visible to everyone where the problems are. This conceals the need for further improvement.

If all four people continue working with the surplus of 0.15 (day), which is the unnecessary activity of waiting, even if it is only for 10 days, this will reset their pace of work. When the next improvement is carried out, they may have a psychological resistance feeling that their work has been increased and become harder.

In our example, as the result of putting together and redistributing the work that had been done by five people, the same work is now carried out by 3.4 people according to calculations. Since there is no 0.4 person, it is still one person.

It is a situation where we have been able to reduce one person and reduce the work of another to only 40%. As described earlier, by reallocation of the work, one person has been reduced.

Our next goal is performing improvements that eliminates the 0.4 person's work. What shall we do to fulfil this 0.4 work without using a person? We focus on that and come up with a variety of proposals.

Among these plans, there are ones that cost money, like "*autonomation*" of equipment, as well as plans that do not cost much money like making a small chute to shorten the waking time, or making the pallets smaller, and putting them within reach.

At this stage, it is important not to choose an excessive plan. The purpose is to eliminate the of 0.4 person's work. The most appropriate plan is the one which *cost least* and is *easiest to implement*. Now the work that used to be done by five people, using a relatively small sum of money, can now be done with three people.

Next, re-examine the production line one more time. If you look closely, you may discover unnecessary activity that has been overlooked. Or possibly, you will find work which is considered non-value-added, which we have no choice but do in the current situation; but since it doesn't add value, it makes you rethink about whether it is possible to stop doing it somehow.

Once you gather these issues together and improve the situation, the challenge is, *"can we take out another person?"* This time, it will not be as simple as before.

If all the possible plans cost too much or affect the preceding/following production processes, perhaps it cannot be realized now. By persistently observing the workplace every day while being aware that "*there is a problem here*," you might come up with a great idea.

It is also possible that the awareness of the issues would help achieving the improvement as new needs arise in the future. For example, when the takt has been changed according to the sales or when there is a facility change due to a model change. It is important to work patiently without giving up, even if it cannot be improved immediately.

Sequence of Improvement

In the previous section, we explained the method to proceed with improvement in this order: Redistributing work by eliminating unnecessary activity → Applying improvement to labor fractions → Further review.

Looking at this as described in the Section 1, the process can be explained:

(A) Immediately eliminating unnecessary activity,

(B) Reduction of work that does not add value, starting from the ones that can be most easily handled,

(C) Leave the Value Adding (VA) work as it is.

When proceeding with labor reduction, difficult parts in **(B)** can be handled by spending money. In the case of the VA work in **(C)**, it is possible to cut down on personnel by autonomation (Jidoka) if the need arises. All the works **(A)**, **(B)**, and even **(C)** can be subject to improvement. Depending on the situation, we might need to implement all of them.

When performing labor reduction activities in the workplace, it does not necessarily have to be done in the order as explained in the preceding paragraph, as far as you keep the following things in mind:

It is more likely that you can improve faster when you conduct the activities concurrently.

What you should be careful about is the order you carry out: you should conduct the work improvement first, and then do the equipment (or facility) improvement.

The improvement plan can be roughly divided into "*work improvement*" and "*equipment improvement*."

"***Work improvement***" includes setting the rules of workplace, redistributing work, and specifying the locations of things.

"***Equipment improvement***" includes installing devices and automating equipment.

When carrying out the improvements, keep in mind that you should start with the work improvement and complete all work improvements, before carrying out any equipment improvement.

The reason is:

(A) Equipment improvement costs money. The objective is to have fewer people. If we spend a large sum of money on equipment improvement, when we could have done fine with work improvement, it could be said that we chose the wrong method.

(B) Equipment improvement cannot be undone. Equipment improvement can end in failure even if we thought it was the best way during planning.

There are some elements involved that can be carried out only through trial and error. If something goes wrong in work improvement, you can easily make changes in the specific part of the process. If anything does not work well in the equipment improvement, you will then lose the money that has been invested for the improvement.

(C) Equipment improvement in a workplace that did not fully undergo work improvement, is likely to fail.

Equipment improvement can most likely fail due to its inflexibility, when implemented in the workplace where organization and standardization of working processes has not been fully done

For example, if we automate a press in a workplace with poor raw material management, the molds and automated equipment could fail right away because of contamination by foreign materials. If we end up assigning someone to watch over the automated machine to solve this problem, then this cannot be considered as labor reduction.

For these reasons, TPS emphasizes you do the work improvement before the equipment improvement. It should be noted that this concept is also true in the case of promoting "*autonomation*" (Jidoka).

Originally, autonomation, or automation with a human touch (*Jidoka*), was equipment improvement with an objective of reducing the cost (labor reduction). There are a relatively large number of cases where autonomation became something like an objective and implemented without considering the progress of work improvement in the workplace.

If the work improvement was insufficient, the expensive autonomation causes troubles and unnecessary activity; for instance, making defective product by lots, considerable decrease of the operation rate due to frequent machine troubles, or, the machine cannot be operated without an operator.

Careful consideration and reflection are needed on how to proceed the autonomation.

Other Important Points

We have explained above about proceeding with labor reduction. In the end of this section, we want to add a few more points. Part of this will be discussed further in the next section, we will summarize only the main points.

Make the problems visible

It is important to keep the workplace well organized and standardized so that the problems are clearly visible and recognizable to everyone. If the problem is clear, it makes easy for all to think ideas of improvement together.

Do not be afraid of stopping the line

In the process of improvement, temporarily confusion may cause line stops. If you are too afraid of stopping the line, it will not be possible to improve the current situation.

Instead of fearing line stops, you should consider them as the springboard for further improvement. It is important to take a quick measure so that the line can be operated without causing stops.

During the process of improvement, it is necessary to not hesitate to stop the line to clarify and solve the problem. This may cause a decrease in the production quantity and the staff may feel upset.

In the assembly line of a certain company, a supervisor achieved improvement by following this method.

During the process, the production quantity that had been 2,000 pieces per day went down to 1,500 pieces per day and the stock was quickly reduced.

Having been criticized by their boss, they started to waver inside. They kept believing that this was the only way to achieve improvement. Because of this persistence, in about ten days, that line became able to assemble 2,600 pieces per day.

While the supervisor of the neighboring line thought about how stopping the line even temporarily will decrease the efficiency, and will be a loss to the company, so they did not allow their operators to stop it.

The improvement of the former line made the unnecessary activity of the latter line obvious. The difference between the lines became large enough even for everyone to notice it.

This is an example that has happened, but you must think thoroughly about how, inside Toyota, or even the lines of its suppliers, the lines that have relatively little unnecessary activity and high efficiency, do not fear line stops.

How to reduce manpower required

Even you have a great improvement plan, it is difficult to realize it without cooperation of the operators. To make the significance of the activities fully understood by the operators and to obtain their cooperation, the following points must be considered.

- **(A)** Help the operator recognize that they have time to spare. An operator who has waiting time, should be allowed to idle for a while without doing anything. By doing so, it will become apparent that they have some spare time. There will be no strong resistance or opposition when they are assigned an additional task.
- **(B)** When reducing people, *reduce the best personnel first*.

We often make the mistake to reduce the person who is difficult to control or those who are not good at or not familiar with the operations. By doing this, the person concerned may never show any development no matter how much time passes and will become conscious of the opinions or expectations of others and will resist them.

Reduction of the person who is doing poorly leads to a decline in morale. By reducing those with the good results, you can obtain active cooperation of others.[17]

[17] Takehiko Harada details this in “Management Lessons from Taiichi Ohno”. The best performer is removed and assigned the task of assisting with further improvements, thus this becomes a reward for making improvements.

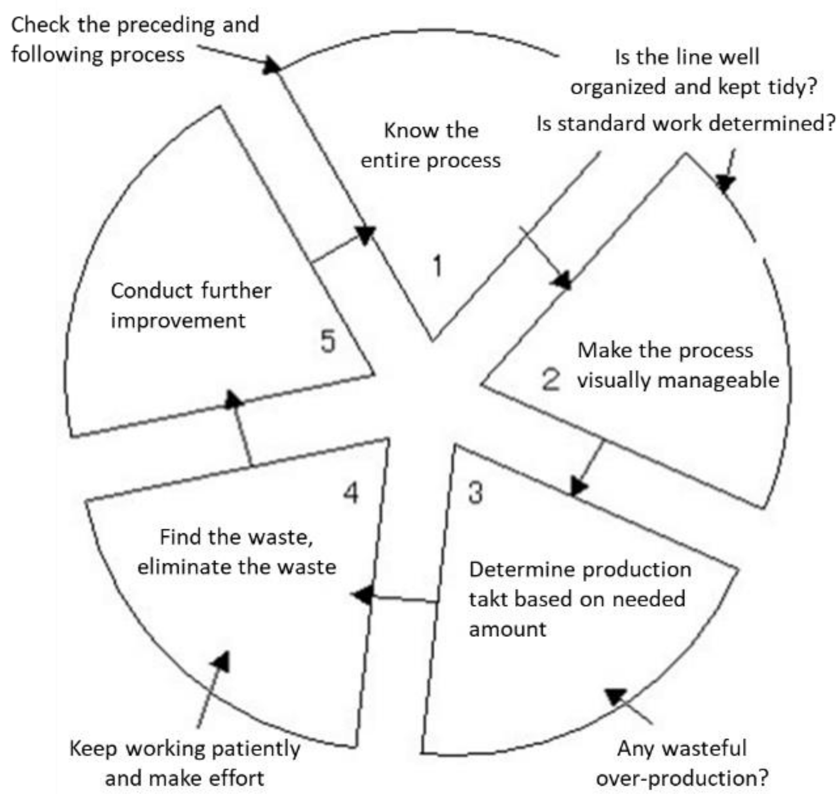
Section 7 - Labor Reduction and Supervisors

Role of the Supervisor

It is said that "*reducing the cost 10% is equivalent of doubling sales*." The cost reduction activities at the manufacturing sites are essential, if neglected, it can shake the company's very foundation.

The role of the supervisor who is responsible for the actual practice of promoting the activities is very important and the weight of their contribution to a company is great.

Recognizing this, we are promoting TPS in Toyota's factories, and executing using the following method of analysis.



When following this circle, we would like to discuss what kind of resolve the supervisor should have when going through this cycle, and what they should do to make sure that Toyota's labor reduction routine is carried out in a manner that complies with the company's goals.

There are two fundamental roles of the supervisor. The first is quality assurance (see Section 2 on Labor Reduction and Quality), and the second is to conduct improvement activities for labor reduction.

This is not as simple as you might think, because it contains elements that seem contradictory to each other at first glance. While you need to secure the quantity and quality, at the same time you achieve this with the minimum number of people and equipment.

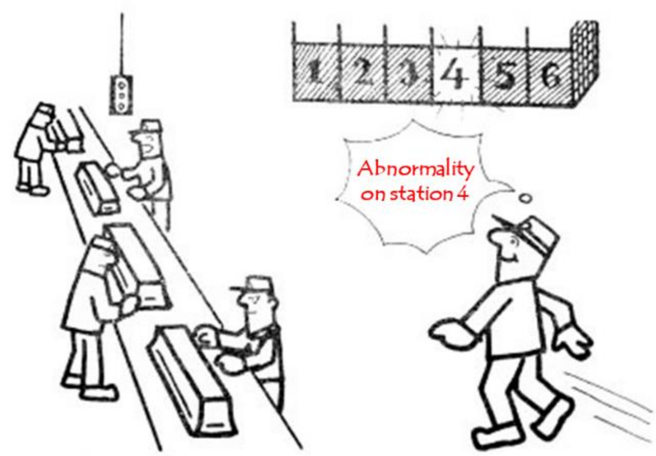
By putting too much stress on securing the production quantity, they would most likely start thinking that they must avoid line stops at all costs from the beginning. So the people, equipment, and stock would increase. Ultimately the cost will go up, as they have strayed from the original objective of the company's routine.

As hard as it may be, the supervisor is required to make effort to improve their production in a direction that satisfies both.

Management of Abnormalities

What methods should a supervisor use to apply improvement to the line so that goods that satisfy each of the quality, amount, and cost, are produced?

First, think about the manner of management. Even though we only thought of few, there are so many things that are subject to the supervisor's management. People, work distribution, teaching the "*know-how*" and quality, accomplishing or adjusting of the production plan, equipment, safety, inventory, arranging raw materials, setup, etc. It would be impossible to fulfill these at once by yourself.



In TPS we teach the standardization of these elements, then focus on the exceptions that deviate from the standard. This is called the management of the abnormalities.

Standardization in terms of the operation phase is deciding on standard work and to follow it. In terms of material and stock management, it is to clarify their designated location and quantity. In the aspect of production instructions, it refers to "*kanban*," while, for safety, it is about criteria of handling. In short, standardization is to set guidelines for each phase of production process to determine how each task must be done by each operator.

By organizing every aspect of manufacturing, setting the standards, and making sure people follow the standards, you can spot those which deviate from the standards as '*problems*' and focus on solving them. The more thoroughly you apply this method, the more it becomes clear what the supervisor should do.

The first thing you should do as a supervisor is to organize the line you are responsible for. To put this in a more detailed manner, this would mean establishing standards, deciding on where materials and parts are to be left, deciding on the production quantity, setting up *kanban*, and installing call buttons, line stop buttons, and *andon*.

Once the standards are set that show the supervisor's intention of "*how to do the job correctly*", then the supervisor must observe what has happened in the workplace as a result.[18]

The supervisor needs to take necessary measures to correct the abnormalities that were not originally intended. It is important to distinguish what kind of activity is normal and what is abnormal.

Although the supervisor may have clearly defined the standards, if they cannot recognize what is abnormal or neglect to correct these abnormalities, then they are not suitable to be a supervisor.

It is important to devise ways so that anyone can tell that there is an abnormality right away. Having an eye for abnormalities is the first step towards improvement. Let me explain this with some examples.

If everyone does their work according to standards, and there are zero defects, they are supposed to have the line's daily required quantity of products by the end of their working hours.

Since the distribution of work is not perfect, it is unlikely that well-balanced workload has been assigned to all the people from the beginning.

For example, operator A has a slight amount surplus. They are waiting every now and then. Or stocks are often piled up behind them. Or they begin to do tasks that are not included in their standard work. These are all abnormalities; operator A *does not have enough work*.

In another case, operator B does not finish their work within time. They stop the line. Or possibly, they cut corners and produce items with defects. Those are also abnormalities. Operator B has *too much work*.

If operator A can do person B's job within the defined time, then that means that the supervisor's method of teaching operator B was unsatisfactory.

Operator C is helping a machine with an automatic feed. (This is an action outside of standard work.) This is also an abnormality. When supervisor examines the abnormality, they find out that the machinery is wearing out. It produces defective products unless the operator puts

[18] To learn more about how Toyota uses Job Instruction, "*Toyota Talent: Developing your people the Toyota way*" is a good reference.

their hands on it. The supervisor should immediately contact the technicians or the maintenance personnel and have it fixed.

Behind the line, there are products that have no *kanban* (work order signal) on them. This is an abnormality.

Probably a wrong pace was set to produce too quickly, or maybe all the people have too much time to spare, or they did not stop producing items although the following process stopped receiving it as something wrong had happened (a violation of the kanban standards). In any case, none of these should be ignored.

These are just a few examples. All of them should be considered by the supervisors who establish the standards, to be abnormalities. In most cases, if the root cause of the abnormality is investigated, it would often turn out that the standard could not be kept because the standard itself was overburdening, the parts or the raw materials were defective, or the equipment was malfunctioning.

The occurrence of line stops, and defects are directly related to quantity and quality, so we can immediately tell that they are abnormalities.

Abnormalities which would increase the cost are overlooked or thought of as a secondary matter because they are small unnecessary activity or violations of the standards.

These are all important clues about improvement that lead to cost reduction. No matter how little they may seem, we need to avoid overlooking them.

Stopping the Line

The first step of improvement is to learn to see the abnormality. If you find the abnormality and clearly understand what the problem is, 50% of the problem is solved.

"*This part is wrong. This has to be fixed*." Once the problem is identified, various ideas how to fix the problem will be proposed by experts who have unique knowledge and skills. By gathering the collective knowledge of the operators, many methods will come out.

You then choose the least expensive, most effective solution and carry it out. "*Making the abnormalities visible and noticeable*" is an essential principle for proceeding with improvements and is a very important matter that the supervisors must devote all their energies.

Next, we want to talk about the supervisor's attitude necessary for this. It is important that you should always be ready to stop the line anytime. This may be a difficult thing for the supervisor to do; but it is necessary.

When you do not hesitate to stop the line, you can recognize the problem with the production process and the poor quality of the preceding process. By telling your operators "*if you cannot* *do it, then stop the line*," you can encourage them to carry out the improvement activities more actively.

This may sound like a paradox; but the aim of stopping the lines is to improve them (stronger and better) into lines that do not need to be stopped. The purpose is eventually to build up an ideal line.

This is for this purpose that you stop the line with financial loss at stake. When the line has been stopped, supervisor must do their best to solve the fundamental problem (root cause).

A supervisor who cannot say "*stop the line*," as well as a supervisor whose line has stopped 2 or 3 times for the same reason both get an "**F**." To solve the problems that have become clear by stopping the line one after another and eventually improve the line as productive as unstoppable is the important attitude and mind set as a supervisor.

It must be kept in mind that "*a line which does not stop is either perfectly good or extremely bad.*"

Implementing the Improvement

Next, we would like to talk about implementing improvements. What we have talked about is discovering problems. To improve the problem, there should be a variety of methods that can be considered.

In selecting the improvement plan, it is significant to begin with improvement of operations before starting the equipment improvement, as has been explained in Section 6.

When an improvement plan has been decided, and it is time to implement it, in many cases the results cannot be known unless you try and see for yourself.

For example, you eliminate the unnecessary work and reduce one person from work that used to be done by four people, then redistribute the work on the remaining three, but there's an extra 0.1 person's work remaining. Things like that are common.

If you push it onto them, saying "*you should be able to do this,*" you will provoke the opposition of the people; they will consider this to be labor intensification (unreasonable – overburden). You have no choice but to focus on how to eliminate this 0.1 person's work and to beat your brains out to find a solution. If you cannot resolve the issue on your own, you should consult your boss and your team. It is also useful to consult the technical staff.

In the improvement process, results are important. Once you set about the activity, work patiently until you finally achieve the reduction of a full person.

If you were going to save about 15 seconds of time, there are many things that can be considered like shortening the walking distances, having the parts storage location closer, making the pallets smaller, or possibly, changing the buttons to one-touch buttons (provided that you take measures to ensure safety in the same time), retrieving the products automatically, or hanging the tools from above; in short, the point is that you should narrow your focus, and continue to persistently think about what to do. In such a case, it is often that a tiny hint triggers a good idea.

Another important thing is that the improvement plan must be well established, the improvement must be standardized as a new work routine. In this sense, an improvement plan is useless if it is a haphazard plan that cannot be stabilized.

To stabilize the improvement, when improving the equipment, jigs and tools, or chutes, you should observe them until they can be fully used in practice. In the improvement of standards, such as exchanging the cutting tool or arrangement of molds, just setting a new standard is not enough; it is necessary to practice it thoroughly, including some minor revisions, until all the operators fully master the new work standard.

When an improvement activity is completed, and the work standard is revised, it is time to start another improvement. We must return to the actual workplace once again and search for abnormalities.

The role of the supervisor is to turn the circle of: Standardization – finding abnormality – investigation of the cause – improvement – standardization. By keep turning this circle, it is possible to fulfill the seemingly contradictory function, i.e., ensuring the quality and quantity and at the same time achieving the cost reduction.

Things to keep in mind as a Supervisor

We will briefly talk about the conditions essential for the supervisor to fulfil their role.

First is observing the actual workplace constantly. A supervisor of the workplace who does not look at the line or who is indifferent to what is happening is not qualified to be a supervisor. If they do not check the standards they determined, or cannot distinguish normal from abnormal, there is absolutely no possibility of improvement.

Second, a supervisor must lead their team. This means supervisor must <u>train</u> the team so that they can work to the standard. As mentioned in the section on human relations, a good human relationship is not built by just earning the favor by being modest and reserved.

The supervisor who teaches and trains people who will eventually become their equals as supervisors one day, and the one who creates a strong workplace as a result, is one who can be trusted as a leader from the viewpoint of their people.

In TPS we ask this question: "*Did you have to produce this inventory, or was it just produced impromptu?*" No matter how much material or manpower is available, it is important that you do not produce if it is unnecessary.

Supervisor should have the leadership to control the team as they need, stopping the team working or giving them the green light. Effective improvement cannot be carried out without leadership.

Third, the supervisor should look at all things from a broad perspective to make a comprehensive decision. No matter how much you say that it was an improvement to your own production process, if it negatively affects the preceding or following processes, or if you must switch from carrying out a troublesome production process to outsourcing, this can never be judged to be improvement.

It is very important for every line supervisor to take into consideration when they are managing their own line, and constantly make overall judgements by looking at all things from a wide perspective.

The best supervisor is one who can do the standardization and promote improvement so that the line can work at its best performance even without them. The ideal supervisor can say: "*Please remove myself from the line*."

Supervisors Working on the Line.

In the end of this section, we would like to discuss the concept of a supervisor doing work in the production line.

We are asked: *"Is it right or wrong to let the supervisor to participate in the line work?"*

In TPS the answer would be: *"It is not good if supervisor is participating in the line work **all** the time; but at the same time, it is not that they do not need to do so at all."*

A supervisor that works on the line every single day is no different than an operator. Such a supervisor cannot fulfill their main role of conducting management, improvement activities, or staff training.

On the other hand, a considerable surplus of people is needed to make it unnecessary for a supervisor to enter the line. Where a continuous effort is made for improvement, it is only natural that there are occasions in which supervisor must participate in the line work. Do not participate in the line reluctantly because you must do so.

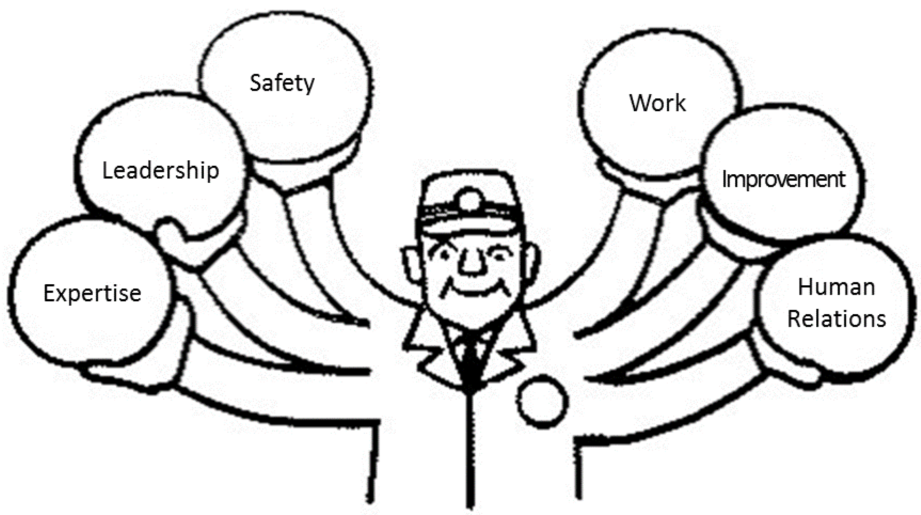
As described in the first paragraph of this section, one of the important roles of the supervisor is improvement activity for labor reduction.

The reason why supervisor must be away from the line work is to see the overall situation, the ultimate purpose of which is to carry out the improvement activities. At the same time, to perform the improvement, supervisor must have full knowledge of the difficulty and procedures of the work.

For example, when new employees join the team, or the work process has been improved and the process has been revised, it is the supervisor who must show and train the best way with least amount of unnecessary movements.

There are unnecessary, uneven, unreasonable tasks that cannot be recognized if supervisor is just looking at the line and does not join the practical working process. Whether it is about guiding their people like this, changing procedures as they see fit, or searching for unnecessary activity, unevenness, or overburden in deep detail and applying improvement to them, there are times where they must work on the line to figure things out. When you have no choice but to work on the line because a person is absent, it is a good opportunity.

The Supervisor must fill all roles



It makes a great difference whether the supervisor joins the production line work reluctantly or willingly takes the chance to polish their skills and to find a possible improvement. This would not only promote the improvement, but also maintain production in the event of the absence of a skilled operator.

Although you may think it is a stern way of thinking, when the chance occurs to join the line, supervisor must always participate in the line work, taking the advantage of learning, with a positive awareness of its significance for further improvement.

Chapter 2 - Efficiency

Section 1 – What is Efficiency?

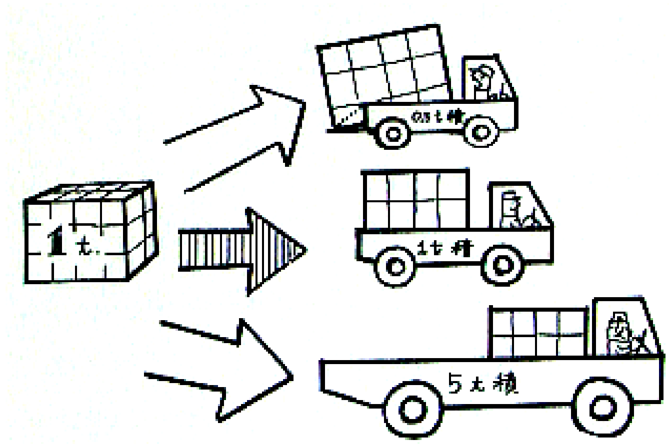
As already mentioned in *Chapter 1*, it is most important for those working in manufacturing companies to reduce unnecessary activities and develop efficient production methods, which reduce costs. We must do our best to eliminate unnecessary activity daily and to raise the efficiency of production through continuous improvement.

We generally use "*efficiency*" as a "*scale*" to measure how much our productivity went up compared to the past because of our efforts. Regarding viewpoints and ways of thinking about various things related to efficiency, it must be well organized from day to day. If you misuse the way of using the standards, you cannot evaluate it correctly.

We might end up facing a situation where cost goes up despite the increase of efficiency. In this chapter, we will explain our way of thinking about efficiency.

Effectiveness and Efficiency

We want to think about effectiveness first. Effectiveness means "*the ratio of the work that the machine can actually do to the energy that it has supplied to that machine, so it is indicated by a number within 100%*".



By applying this way of thinking to production, we refer to the effectiveness of production, which is *"for a certain product, it is the percent ratio between the labor (energy) that turned into a product (or possibly the labor needed to proceed with the production processes), and the labor that was actually consumed to produce it."*

To say that effectiveness of production is 50%, only 50% of the person's efforts are producing the product (or to advance the process), and the remaining 50% is unnecessary. Speaking of 80% production effectiveness, 80% of the person's efforts are useful, so production effectiveness is quite high when compared to the previous example.

Effective production means that most of the effort that everyone makes is an effort that creates something (or increases the value-added), and this is positive.

When you consider it, everyone works as hard as they can when they start at a company. But when you look at the nature of their work, for example, piling things up here, lining them up there, carrying parts off the pallets in small amounts, arranging them together; there are times when they labor in work that is completely irrelevant to the progress of the other processes. There are times when you are sweating. Although we are producing products at very high speed, about half of them are defective and require rework. They are trying hard, but these are examples of low work effectiveness that does not lead to added value. This is an unnecessary use of precious energy, and this does not make good use of the people's true capabilities.

The supervisor is the one who decides on how work is done. If the effectiveness of the work is low, it is the responsibility of management. Management, supervisors and staff must keep improving the contents of the work daily so that the people can be highly effective in their work.

Assume that a lot of effort has been continuously made towards improvement, and as a result, the *effectiveness* of the production goes up and we started making relatively more items than we used to. In cases like this, we say that the efficiency of the work has improved.

Efficiency is used to compare yield, as in how many items, and with how many people, we made within a unit of time (for example, per hour). In this case, our reference (standard) is often something derived from the achievements we have made, like the previous month or the average of the past six months. It is used as in "*This month, our efficiency went up by 15% compared to the standard*." Unlike effectiveness, it can go above 100% at times.

We often see many ways of expressing the ratio between the *work results* and *effort* spent in a company. Other than "*Efficiency*," there are many different measures used to evaluate whether work is progressing effectively or not, such as "*operation ratio*," "*labor productivity*," "*hourly rate*".[19]

There are two or three points which we should particularly pay attention to when we are using such *measures* to evaluate the *results of work*.

(A) Whether you use operation ratio or hourly rate, raising these values is not the objective itself, your objective is cost reduction.

By ignoring all kinds of conditions and raising the operation ratio or the hourly rate, depending on the situation, we could end up increasing the cost.

[19] OEE (Overall Equipment Effectiveness) a standardized factor to assess as a single value the Availability, Performance and Quality; it is expressed as a percentage.

For example, to raise a line's operation ratio, we can resort to methods like making each process have intermediate work in process that is enough to cover up any minor equipment failure, or keep large amounts of all kinds of product parts, and make it such that both parts as well as their setting methods are available to avoid being affected by a stock out in a preceding process; doing things that way can probably be thought to increase the operation ratio.

Through our past 30 years of experience in workplace management, we can tell that these methods often lead to increasing the costs. It is essential to keep in mind that we can use these "*measures*" effectively only if we constantly make it clear whether they coincide with our objective, and fully understand the conditions of each when using them.

(B) The way we regard efficiency is extremely important.

When it comes to mechanical equipment, they are most effective during the machine cycle time (the uninterrupted machine operation time). We need to clearly find out where the machines we are currently employing stand in terms of capacity, and we should keep in mind that we can increase their capacities if we ever need to.

In the case of people, it is necessary to separate *movement* and *work*. Within the cycle time, even if the people are continuously moving, we can always divide that into things we need, and things we do not. The former is a movement that increases the value-added (in TPS we refer to this as "*work*" to differentiate it from simply moving), as well as the indispensable movements that are connected to it, while the latter includes all other movements, ones which bring no harm if they are omitted. This is what we call "*unnecessary activity*." Do not think of this as the ability of a person, while unnecessary activity is still included in the process.

(C) It is important to sufficiently consider the sense of time, as in "*being faster*."

Performing work faster only bears meaning once it allows for handling even more processes; hence performing work with fewer people overall. Making products faster, thus making more, can lead to an increase in efficiency. Depending on the situation, this could result in losses. As we discussed in the beginning, efficiency is just another "*measure*." We must only use it while checking it against our objective.

Objective is Cost Reduction

As mentioned in the previous section, the objective of improving efficiency is in reducing costs. If increasing the efficiency became the objective, there is a risk of making management mistakes. When high efficiency coincides with low cost, there will be a meaning in improving capabilities. For this reason, you must always have your eyes focused on having those two things meet, and then act.

For example, we often see work sites that set raising the pieces per hour as their management target.

Note: This is not a ratio but since it is used as a scale to measure productivity, it could be seen from the same point of view.

A production line has been using a method of putting a blackboard at the end of the line and writing down their production output every hour.[20] If the workplace continues to do this, before anyone would realize, they will end up falling for the delusion of increasing the hourly rate itself becoming their objective. To increase the hourly rate, you must keep setup changes to a minimum, and to produce using large lots.

Even if today's share has been already produced, and if there is still time left, they continue producing the next day's share, and even the day after. Certainly, the hourly rate would go up; but does this really lead to cost reduction? Those doing the work believe that their high efficiency is bringing profits; this only leads to increasing the mountains of inventory between them and the following production process.

The first condition for this line is to produce using lots that are as small as possible that correspond to the intake of the following process, and to produce the required amount only. Only if you increase the hourly rate under these conditions, will result in cost reduction. While removing these conditions and simply increasing the hourly rate, will affect the whole production plant negatively instead.

This means that high efficiency and low cost are not always equal. In relation to this concept, we differentiate between the operation ratio/operational availability in TPS in the following manner:

Operation Ratio and Operational Availability

Operation ratio is the actual production results of a machine at the present point in time, in relation to the ability of this machine when it is fully operating.

It is natural for the monthly produced number of units to fluctuate, since there are times when it decreases if sales are deteriorating, and the opposite, there are times when you must reach 120% or even 130%, through long overtime hours, or extra work shifts, when there is high demand. (The full regular time operation equal to 100.) Raising the operation ratio when not necessary is a big loss.

Operational availability means to be in a state of being able to operate whenever you want to do so; and having 100% operational availability is the ideal. For this purpose, preventive maintenance must be carried out reliably, and you must aim to shorten the setup and changeover times.

You must strictly differentiate between operation ratio and operational availability when you consider things. To understand this way of thinking, apply this on the car you own yourself,

[20] It is common to see screens that display the hourly production rates of a production line.

and it will be easier to comprehend. Operational availability is the ratio that expresses the state of the car as it runs in good condition when you ride it whenever you want to; it is desirable for this ratio to be 100%. The operation ratio is the ratio of how much time you drive the car each day. Since everyone drive their cars only when they need to do so, we cannot say that 100% operation ratio is the ideal. If you drive it around from morning to night without any purpose, this will only lead to increasing your gas and oil consumption and the chances of having an accident will also increase; so, it will be a loss.

We can say the same about the production amount and number of personnel. If you express the relationship of how much to produce using how many people in the terms of efficiency, which of the options will directly lead to cost reduction. We must make it clear that increasing efficiency and cost reduction are not necessarily equivalent to each other.

True efficiency and apparent (calculated) efficiency

Consider the following example: The line uses 10 people to produce 100 items per day. By applying improvements on this line, the capacity went up so that it can produce 120 items per day with 10 people. This is a 20% increase in efficiency. The implementation of this improvement came at the time when production quantity was needed to increase to 120 items per day.

In this case, we managed to avoid increasing the number of additional people needed by two, while being able to raise the number of items produced. Thus, it is an improvement that leads to profit.

What would happen if the production requirements stayed as 100 items per day, or even lower to 90 items per day? When this happens, if we make 120 items per day just because our efficiency was improved, we would have 20-30 extra items per day. Not only will we be consuming the raw material costs and labor costs before we needed, but the pallets, storage places, and labor required to manage this inventory would also go up, which would be an extra cost for the company. This would be an improvement that does not improve the company's results. It becomes a change for the worse.

What should we do to improve efficiency in a way that leads to profit, even if the required production amount does not change or if it decreases? We must apply the improvement on the production process to produce 100 items per day with 8 people (if the required number is 90 items per day, then we will do it with 7 people.) This will improve efficiency as well as reduce costs.

We have two ways to make the same efficiency improvement. One way to build 120 items per day with 10 people and another way to build 100 items per day with 8 people. Both methods represent about 20% increase in efficiency, but we must not forget that we are choosing the method based on how many items that <u>need</u> to be produced.

These two methods, which may look similar according to calculations, show a great difference when they are implemented in a line. The method of increasing efficiency by raising the number of units is relatively simple, and most supervisors can carry it out. The method of increasing efficiency by decreasing the number of personnel is several times more difficult. When we think we should increase efficiency no matter what, we tend to ignore the required amount, and pick the former method.

In many work sites we often see inventory piling up behind a line like a mountain because goods are produced at high speeds under the enthusiastic cheers of raising efficiency; we believe that one reason for this is forgetting that the required amount is the primary principle, and the other reason is that raising the efficiency by increasing the amount is easier.

If we attempt to increase efficiency with this method when production should be reduced, we will be having an increase in expenses on one hand when sales are decreasing on the other hand, and in the worst-case scenario, this could be fatal for a company. (The blow is especially painful in small to medium enterprises.)

In TP the method of raising efficiency by increasing the amount, when the required amount is unchanged, or when production is to be reduced, is referred to as the "*apparent efficiency"* (an increase in efficiency that is only based on calculations,) and it is considered as something that we must never attempt.

When we must increase efficiency by reducing labor, then we must take that challenge, no matter how hard it is. If we become capable of doing things this way, increasing efficiency during times when production is to be increased would be incredibly easy. In this sense, we can say that periods of reduced production are a chance for the management, supervisors, and staff to grow stronger.

"Production volume = required number" is a major principle

Now that we have discussed it, we must consider what the "*required amount*" is. As we have explained in the previous section, there are two methods for increasing efficiency. One is to increase the production quantity, while the other is to reduce the number of personnel.

In actual lines, if it turns out that choosing either of them works, then most lines would go for increasing the production quantity. This method is less troublesome, and only little resistance will be shown towards it.

While this method is appropriate in lines which increase the production quantity month by month, or those which have had their hands full with overtime work because of their lack in capacity, applying it to any other case would bring about unnecessary activity of overproduction, and would lead to an increase in the cost as we have previously explained.

We have said this over and over, our objective is only cost reduction, so when it comes to increasing efficiency, the method that complies with this objective must be chosen.

To eliminate the unnecessary activity of overproduction and reduce the cost, the production quantity and the required amount must be equal. What do we use to decide on the required amount? That would be the demand. It is decided by the trends in the market. For a work site, it is something to be taken as is, and they must know that they cannot just increase or decrease the amount on their own.

The increase in efficiency that is to be carried out in the production site, must regard the required quantity as a premise, and achieve this increase within its boundaries.

When using efficiency as a scale, its foundational concepts must be as described above. Once we have sorted that out, we will be able to avoid the emergence of the unnecessary activity of overproduction. Then it will turn out that *"Increase efficiency = Cost reduction."*

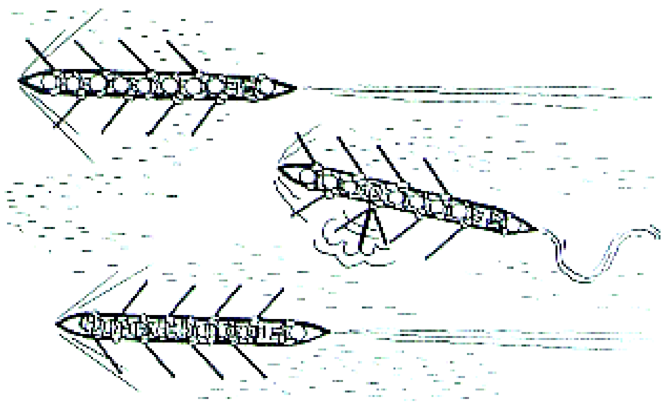
We would like to have a more detailed look at improvement in situations when the required amount has not changed from that before improvement, or when it has decreased. Increasing efficiency while aiming for labor reduction, will only be achieved through reducing the unnecessary activity in the operations done within the Takt time derived from the required amount, getting people to do their jobs (work) as much as possible, or automating a part of the work done by people and getting them to do some other work instead, then summing all of that up, and carrying out the production routine with even less people.

The money for mechanical equipment, jigs, tools, and transportation equipment, would have already been spent, so they should have no future effect on cost, regardless of how they are used. We should just use them according to the Takt time that is derived from the required amount, and the operation ratio should be decided accordingly. This was described in the previous section.

Section 2 - Individual Efficiency and Overall Efficiency

The general idea of efficiency was mentioned in the previous section. Before concretely applying this to the factory, consider one of the following examples.

The boat race we have in our company every fall, is an intriguing example when we are considering efficiency. The boat can move at a great speed once the eight oarsmen are moving in complete synchronization. The normal pitch is about 40-50 strokes per minute, and they should maintain it by following the signal. We can say that a boat race is about how good or bad the eight oarsmen are at keeping synchronized.



What would happen if one of the eight oarsmen said, *"I am strong, and I have the skill, so I am going to row with a pitch of 60 strokes!"* and then he started rowing faster only by himself? His original intention was to increase speed, but that resulted in their balance crumbling, and they became slower instead.

The total force of the eight people which is moving the boat forward went up a little, but the effectiveness dropped. If the eight oarsmen were to row randomly at their full power, the boat would not move forward evenly. In a boat race, the most effective method is for all members to maintain the pitch together; having an individual row faster is as bad as having an individual rowing slower.

The way production works in the workplace is very similar to a boat race. The pitch is the production takt time, and by maintaining it while producing, the overall efficiency would go up.

If one operator or one line were to ignore the takt time and increased their production speed, the calculated individual efficiency may go up, but the overall efficiency would drop.

Consider this by concretely applying it to the factory. The smallest building blocks of a factory consist of the individual people and each piece of equipment. When they are gathered around a part or a process, a production line is formed.

When several lines gather together, along with the surrounding departments such as transport, inspection, and maintenance, as well as the engineers and the staff, they form a factory.

When considering efficiency with the goal of reducing costs, it is necessary to improve efficiency at all levels. That is because every single person and every single process throughout the whole workplace are very closely connected in all directions, and there is almost nothing that stands independently.

One person's method of working could affect somebody else, and one line's production method could often restrict the preceding and/or the following processes, as well as transport operations. When discovering unnecessary activity and pursue its cause to eliminate it we often reach the issues in the preceding, subsequent, or transport processes.

It is not just about an individual, or their own process, but it also shows us how this has a great influence on how good or bad the efficiency of the following and the preceding processes would be. Even if efficiency improvement leads to cost reduction, an efficient way must be done at all levels.

In this section, we will briefly discuss increasing the efficiency on each level.

Efficiency of the Work of Each Individual

The important point at this level is the idea of "*value added ratio*". The ratio of work which increases the value-added, throughout all the work the person performs; which means that the greater it is, the higher their efficiency would be.

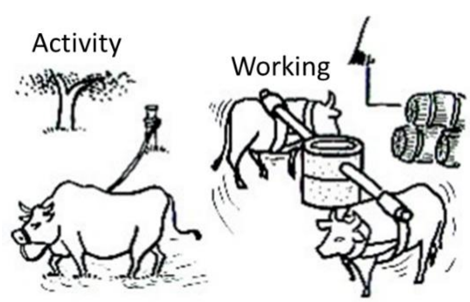
For example, work such as trans-shipping goods, unwrapping, and folding wrapping paper over, is originally unnecessary work. By omitting those, and only picking up work that is essential, the ratio of the work that increases the value added within one cycle of work would go up.

As related to this section, TPS has the following idea.

The Difference between Work and Activity

In Toyota, it could be said that we were more active than the Westerners. And yet, we were behind when it came to labor productivity.

We may have been more active, but we were producing less value adding work. The effectiveness of our work was lacking.



For example, we are working in production activities for 7 hours, 30 minutes a day, but there is too much time that is not considered work within these production activities.

In TPS only when processes progress, and the job is fulfilled (when the value-added goes up), can we say that work has been done. Work is movement coupled with human knowledge, and we can also say that it is when the people are provided with their supervisor's knowledge.

On the contrary, we do not refer to operations which bring no harm when they are omitted (ones that do not increase the value-added) as work, but rather, as movement.

Labor Density

It is important for everyone to make efforts to convert movements to work, and conversion will lead to a reduction in labor.

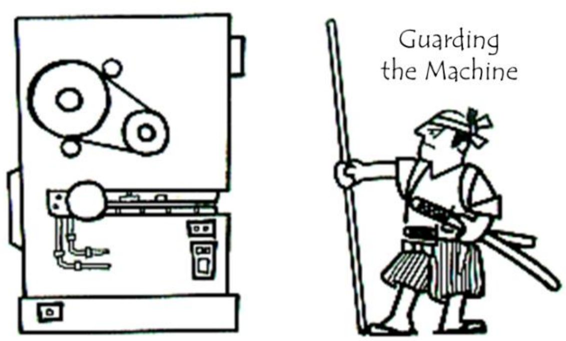
In TPS we perceive labor density as *"work labor divided by movement labor"*, and when this ratio is high, it means that much of the person's energy is allocated into an important job, which would be something favorable.

This is an easy-to-understand example as to what to emphasize on reducing labor, so I will open it here.

Automation and Autonomation [21]

Automated machines move even without people. What is just as important as moving, is to stop in case of abnormalities.

A machine that does not stop will keep producing defective products, and there is a high possibility of it breaking down because of working in vain when there is nothing inside or because of foreign matter contamination. We must assign someone to watch over it no matter what. And this person does not do any kind of job that increases the value-added.



In TPS we clearly differentiate between a machine that only moves (automated machine), and one that can automatically stop (autonomated machine) when it detects an abnormal condition. This is the spirit of Jidoka which has been traditionally accepted since Sakichi Toyoda's invention of self-stopping loom.[22]

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[21] Also known as 'Jidoka'.

[22] The core idea is not about the invention itself, but the idea that you want to make the machine 'self-tending', not needing someone to guard it or babysit while it works, and the person waits. This fixes the waste of waiting. *Note: His 'invention' was not new, an American company had patented this nearly 20 years earlier.*

When you spend so much money to achieve autonomation, there must be a befitting return (labor reduction). It would be a problem if we end up with automation instead.

We must apply one improvement after the other and make effort so that we can bring it into the realm of autonomation.

Autonomation (自働化) includes human knowledge (a human radical 亻), while automation (自動化) includes no human (亻), so it needs someone to watch over it, so we can remember them like that.

We must carry out autonomation, even in processes which contain a lot of manual labor, such as final assembly conveyors, by making an interpretation of these concepts.

In this case, the "character for 'self 自'" refers to the person, and it means allowing the person themselves to stop the conveyor if they ever think "*this is not right!*" or "*this is a defective product!*" throughout the work they are performing.

If we were to put it in an extreme way, every single person would be carrying a line stop switch, and the moment they think something is odd, little as it may be, they would stop the line immediately.

Producing defective products or products that do not pass that standards, will not be considered as doing one's job. It will not be considered as work, and this is one more viewpoint of autonomation.

Efficiency of Work in the Production Line

There are two important things at this level:

Balance between Processes [23]

This means production according to the takt time and avoiding overproduction. When some people set their own high efficiency as their aim and produce quickly, products will pile up in front of the person of the following production process, and the work of sorting these out will increase. They might start to have a feeling of impatience, and mistakes will increase. If you look at the whole production the line, the efficiency will decrease instead.

When there is work that is done by several people in sequence, there is always a production step that is considered the bottleneck, and it represents the capability of the line. To increase the efficiency of the whole line, you must help the people of this bottleneck production process; since those who can work fast keep producing, items keep piling up in front of this bottleneck process. This will hold everyone back instead and will cause efficiency to decrease.

To prevent this, you must clearly decide the standard work content and accordingly, you must make everyone abide by the standard in-process stock, the takt time, and the work sequence,

[23] Flow Principle #3 – Balance Work Content.

and since by doing that there will be waiting, you must do compositional changes and keep the balance. For steps that involve working in a row like presses, it is essential to modify them such that the conveyor stops when a part enters within the reach of the person's hand.

Cooperation (relay races of swimming and track)

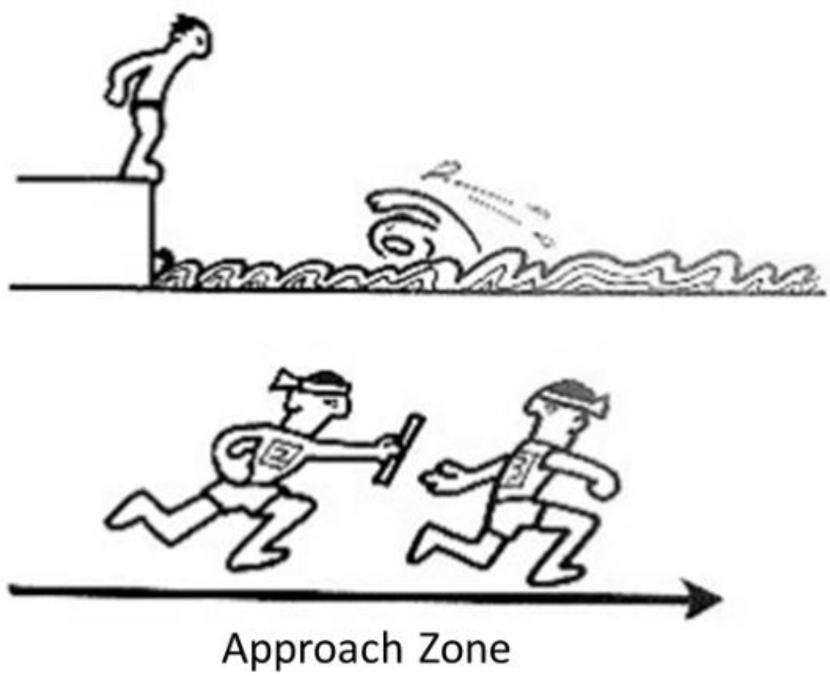
In the above-mentioned manner, it is often that it is impossible to completely balance the people. It is unavoidable to have a little imbalance in the work of a production line that has several people.

In this case, it is possible to increase the efficiency of the whole line, by having those who finished earlier aid those who are still behind.

Even if you have already allotted the production processes, it is desirable for the boundaries between them to be flexible to allow for cooperation.

For example, if the previous process is completed a little earlier, you should devise a way to put the product in the jig of the next first step. As for this way of thinking, please refer to the way of swimming and Baton Pass of the Relay Race as a reference.

In the relay in swimming, after the first swimmer touches the pool side, the second swimmer jumps in. In track there is a 20-meter baton pass zone and handing over the baton anywhere inside this zone is acceptable.



In swimming the slower individual and the faster individual must do 100 meters each, while in track, it is possible to use the "*strategy*" of having the faster individual run 120 meters, while the slower one runs 80 meters.

The work done in the actual workplace must be like a track relay. It is desirable to create a *baton pass zone* so that the supervisor can have a "*strategy*" that increases the efficiency.

Efficiency of the Whole Factory

Sometimes we come across examples where the efficiency of the factory does not increase in companies that put a lot of effort in increasing the efficiency of every individual.

Despite the manual labor of the people being splendidly fast, the inventory is piling up in the factories, and this requires many people to sort out everything, and as an overall result this leads to the cost going up.

This is because productivity only applies to the work speed of the individuals, while ignoring the overall condition. The efficiency of people, same as the efficiency of the line, and the efficiency of the factory, all affect the cost greatly. It is essential to give the most priority to increasing efficiency on the level of the entire factory. To improve the efficiency of the factory certain rules are necessary.

This is not something that can be done by one supervisor or one staff member alone. For everyone to move in the same direction, standards of thinking become necessary. The standard is "*leveling production*" in TPS.

In the case of teamwork, it must be a track relay. The supervisor is advised to create a baton touch zone, so that "*strategy*" can be created to improve the efficiency of the team.

Production Leveling

For a production site, the more the flow of products varies, the more unnecessary activity occurs. That is because equipment, people, inventory, and everything else must meet the necessary production peak and be prepared accordingly (capacity planning to meet peak demand).

If it is built in such a way as to disturb the pace in any step, unnecessary activity occurs, and the efficiency decreases, which is not only a problem, but it has a serious influence on the preceding and following process.

To explain this in an-easy-to-understand example, what would happen if a final assembly line was concerned only with the efficiency of its own process, and decided to go with producing sedans today, hardtops tomorrow, and vans the day after that?

The production line of preceding process that is working on sedans has work to do today, but the line working on the hardtop or van parts, have no work until tomorrow, or the day after respectively.

Having no other choices left, they reschedule their production plan so that they have work to do day by day using their inventory, but even if they do so, they will at least need inventory that equals 3-4 times of what they would have needed if the assembly line assembled the average amount day by day.

By doing so, increasing efficiency can't even be dreamed of. This is what it means to do production leveling. Leveling includes reducing the variance of types of goods and eliminating variations in quantity, as well as reducing the lot of transportation and eliminating variability.

Small Lot Production

Manufacturing processes of automobiles have many processes ranging from casting, forging, rough shapes such as presses, machining, welding, intermediate processing, painting and assembly. To what extent leveling can be accomplished, including all these steps, is just how far we can improve the efficiency of the whole factory.

For instance, metal-casting (die casting), forging, presses, and heat treatment are process that leave no choice but to be done using lot production, and for a long time, there has been many cases where they have been treated as a separate matter, despite being processes that need to receive the most efforts when leveling.

Lot production components are excessively fixated on the hourly rate and the setup times, and they think that having excessively large lots leads to increasing efficiency. Enlarging the lot confuses the process before and after (in this case not the lot production), it generates excessive inventory and much unnecessary activity. Regarding lot production components, it is important to make the lot as small as practical and make efforts to level production.

Section 3 – Increasing Efficiency by Eliminating Unnecessary Activity

Waste of Capacity

If we were to sum up what we have discussed in sections 1 and 2, we will end up with the following:

(A) Improving efficiency is meaningful only when it leads to cost reduction. To achieve that, we must move in the direction of "how do we make only what we need with few people?"

(B) When we regard efficiency in terms of every single person, as well as the lines at which they gather, and the whole factory which is centered on these lines, then we must proceed with ideas and viewpoints aiming to increase efficiency on each of these levels; the overall results must go up as well.

Next, we would like to consider what we should exactly do in a more easy-to-understand manner.

For example, in a line, 10 people make 100 products a day. Based on this current situation, the capacity of this line is 100 per day, and the productivity per person would be 10 items a day. If you look closely at this line and the people, you will find overproduction or waiting time, or we can find variations depending on time and day.

Assume we applied improvement to these and reduced 2 people's worth of labor. The capacity would seem like it has gone up, compared to how it used to be. (If we do not remove the two people, we will be able to produce 125 items per day, so it would seem like capacity has gone up by an additional 25 items).

We had the capacity to produce 125 items per day from before. But it is just that the 25 items worth of capacity was wasted by things like unneeded operations or overproduction. It is appropriate to think that we were able to make only 100 items a day because so much hidden unnecessary activity was included.

Whether we are looking at it in terms of every single person or the whole line, if we consider what really needs to be done as their jobs, and anything other than these as unnecessary activity, we would have the following relationship:

Current Capacity = Useful Work + Unnecessary Activity

The more we get rid of unnecessary activity, and increase their jobs in an equivalent amount, the more we will approach the "true capacity" (100% value adding work as the true capacity). When we do that, we will make more products with the same line configuration.

We must not make more than the required amount. Reduce the number of people to reduce excess capacity to make exactly what you need. This is the same when it comes to each person, to the production line, or for the whole factory.

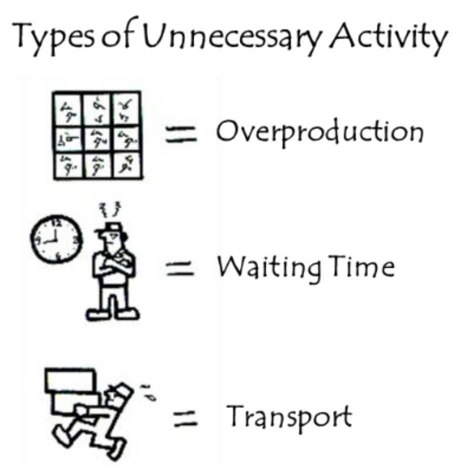
For each person, we focus on the work that adds value and the work that absolutely is necessary in relation to it and avoid other unnecessary activity. On the line, we allocate highly efficient work in order, and eliminate labor fractions (fractional person labor) by improvements. When it comes to the whole factory, we try to establish an overall balance around such lines, make the lots as small as possible, and prevent the emergence of extra transportation costs by carrying out production leveling.

Simultaneously, we apply improvements that prevents the increase in the labor for investigations and readjustments due to frequent occurrences of defective items.

If such actions are taken, unnecessary activities will disappear gradually, so the people, the lines, and the factories, would be able to do an amount of their necessary jobs. Their hidden capacities would come to light. If we carry out labor reduction now, the efficiency will go up as explained in Chapter 1, Section 3.

When we start thinking like this, we can see that raising efficiency means saving unnecessary activity. A thorough exclusion of unnecessary activity is the most basic thing that we must do.

Types of Unnecessary Activities



Within the TPS labor reduction routine, there are four categories of unnecessary activities we want to remove:[24]

(1) unnecessary activity of overproduction

(2) unnecessary activity of waiting time.

(3) unnecessary activity of transport.

(4) unnecessary activity in processing itself.

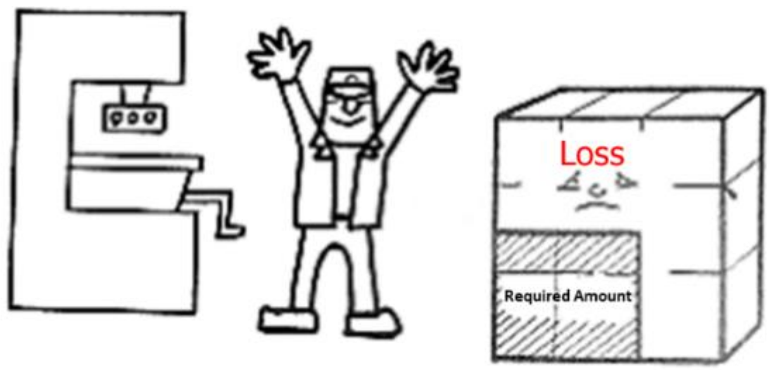
We will explain them one by one.

Unnecessary Activity of Overproduction

It is unnecessary activity to make extra things. The unnecessary activity of this overburden is often caused by excessive progress of work in normal cases. Even though it is time that I must wait normally, I start the next task.

[24] These four categories were further expanded and subdivided into what is commonly referred to today as the '7- Wastes'. The objective of defining them was to make it easier for people to see where improvements needed to be made.

For example, the work of loading and unloading that is seen between one person and the other, or in the connection of one process and the other, and these lead to the causes that increase unnecessary activity. These are the cause of unnecessary effort. Unnecessary overwork such as additional machinery, advanced use of materials, unnecessary replenishment of people, interest burdens, wide warehousing and transportation expenses is not limited to self-process, but also causes other unnecessary activity.



There are many other causes for the unnecessary activity of overproduction. We can think of the following examples:

(A) When you allow for surplus in work, or when there are waiting hours, as a result, work progresses more than required in this time.

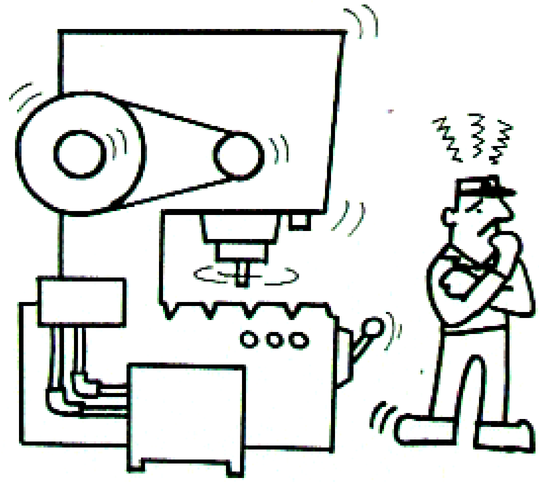
(B) When production is accumulated just because there is still room for this regarding the capacities of the machinery (equipment).

(C) When the overall efficiency is ignored because of running after increasing the hourly rate.

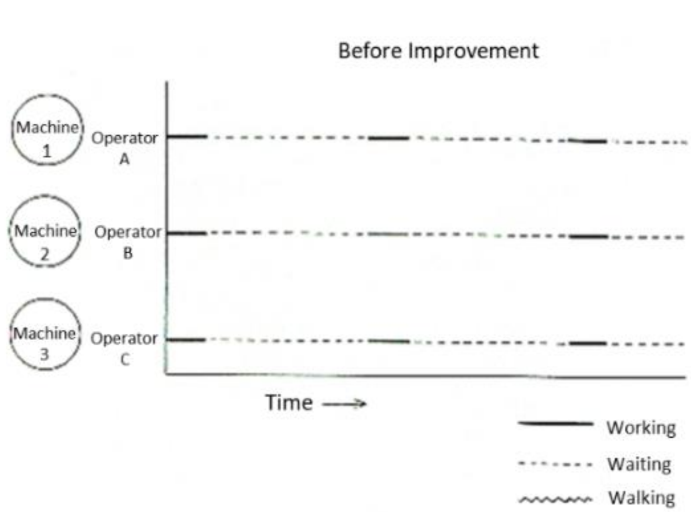
(D) When you adopt the false idea of "*This machine is expensive, so if we do not increase its operation ratio, we will not be able to compensate for it.*"

Unnecessary Activity of Waiting

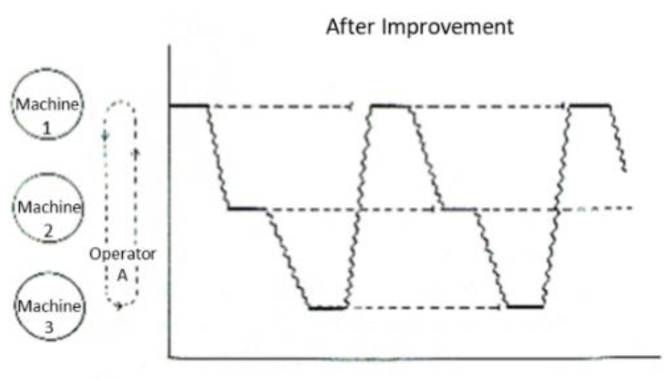
When machines are processing automatically, people are just standing and watching machines, even if they want to work, the machine is running, and they cannot leave. It is unnecessary waiting that occurs.



For example, before doing improvements, one person has been assigned to each one of the machines 1, 2, and 3.



In such production processes, while the machines are doing the work, the people just stand idly, and cannot do work even if they want to do so. The unnecessary activity of waiting time is taking place. To eliminate unnecessary waiting, we decided to have one person do the loading of all three machines in sequence.

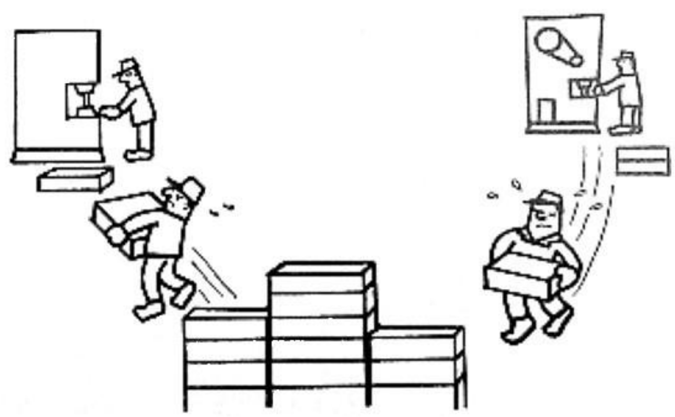


Which means, operator A will install the materials for the first machine, and after pushing the start button, they will move to the second machine. Then they set the materials for machine two and start it. After that they will move to the third machine and set the materials in the same manner as machines one and two, start the machine, and then return to machine one. When operator A returns to machine one, machine one will have finished its work, so operator A will be able to start working immediately, waiting time does not occur.

By eliminating unnecessary activity of waiting, two people can be reduced. Movement without which the "*work*" can still be done, such as lost motion, should be included in that. (Combining work will be discussed in detail in Chapter 3 - Standard Work)

Unnecessary Activity of Transportation

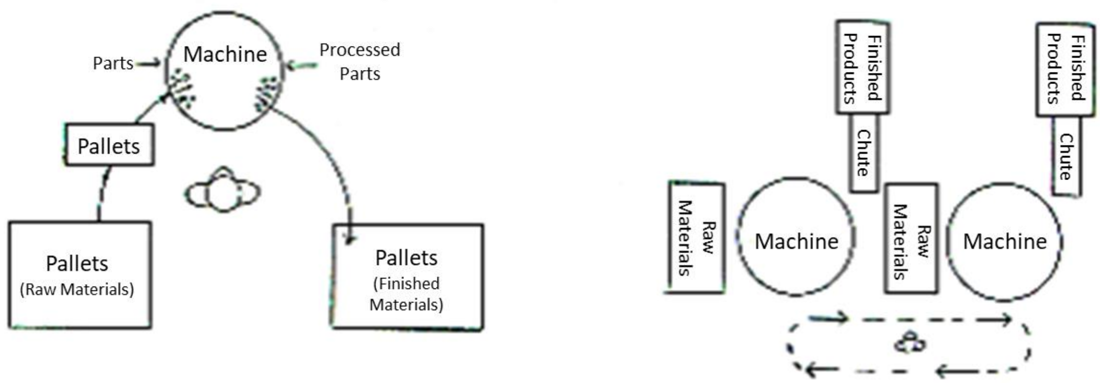
The unnecessary activity of transport is an unnecessary transport distance, temporary placement, for trans-shipment and movement. It is about unnecessary activity that occurs.



To eliminate unnecessary activity of transportation, you must keep the transport distance as short as possible and eliminate temporary placement.

As an example, parts were transferred from a large pallet to a small pallet, and temporarily placed on the machine (on the bed of the lathe) for temporary placement, not the pallet. By eliminating these temporary placements (eliminating unnecessary activity of transportation), we improved one machine so that one person can operate two machines.

Also, from shipping warehouse to factory, from factory to machine side, from machine side to operator's hands have been repeatedly transferred and moved, but these can also be said to be unnecessary activity of transportation.



Unnecessary Activity in the Process

For example, the work is done while the jigs are supported by the left hand, and for that reason the manufacturing of goods is not progressing smoothly, and the wasted time is increased.

This is unnecessary activity of the processing itself. As an improvement in such a case, it is important to repair the jig as soon as possible.

Discovery of unnecessary activity is the first step towards increasing efficiency

We have already discussed how the TPS's central ideas are all about elimination of unnecessary activity, and that it can be roughly classified into the four types in the previous section. When you consider each of these four, you can see that there are unnecessary activities that are easy to find, and some that are not.

Few managers and supervisors let their people do unnecessary activities while being aware that it is not useful. In most cases they regard it as necessary work, or just lack understanding.

No matter how much they think "*Let us eliminate unnecessary activities!*" if they do not understand where the unnecessary activity is, they will not be able to proceed with its elimination. What really matters is making unnecessary activity visible to everyone.

That is the first step to increasing efficiency. In the previous section, the easiest unnecessary activity to find among the four types would be that of waiting time.

For example, within a three-minute takt time, if a minute of waiting time emerges with every cycle, not only the supervisor, but the person and the senior managers can tell that there is surplus time available.

If the operator moves around as if they are doing work throughout this minute, it will be harder to tell (unnecessary activity of transport and processing). If the next product is processed in this minute, nobody would be able to tell whether it is an unnecessary activity or not (unnecessary activity of overproduction). <u>All four types of unnecessary activities need to be changed into waiting time</u>, so it will be easier to put together countermeasures.

To do that, we consider methods like:

(A) Making the operator follow standard work thoroughly, and not letting them do anything other than standard work.
(B) Restricting them from getting far ahead, using a production system that utilizes Kanban (production signals).
(C) Specifying a work space on the conveyer, thus preventing the operator from handling items ahead of time.

We will leave the detailed explanation of these methods to another chapter. What is important here, is that we must be fully aware that to eliminate an unnecessary activity, finding it comes first.

We must be aware that we should constantly maintain the workplace so that any unnecessary activity is easy to find. These can be very minor matters at times, for example, there are times when the matter in question is just a single piece of inventory. Every increase in efficiency leads to cost reduction, it is important to think about why an item was made, even if it is a single item. Sometimes it is enough to think that this will serve as a clue for improvement.

In this section, we have discussed how increasing efficiency is carried out by eliminating unnecessary activities. We believe that there are still other ways to distinguish unnecessary activity, but the focus is that we should try changing the different types of unnecessary activities into waiting time, which is easier to see. We would like to repeat and emphasize that this is the first step to increasing efficiency.

Chapter 3 - Standard Work

Section 1 - Standard Work

Regarding Standard Work

By considering equipment, location of machinery, together with our processing methods, and by devising autonomation, improving jigs, considering transportation methods, adjusting our stocks of work-in-progress, we carry out a thorough elimination of unnecessary activities.

We incorporate the workplace knowledge into matters such as preventing the recurrence of defects through poka-yoke and strive for efficient production methods. The workplace requires something to become the foundation for efficient production and the basis for improvements; this is standard work.

In standard work, it is necessary to consider all the necessary conditions to carry out efficient production. By considering various conditions and combining materials, machinery, and personnel in the most effective manner. We call this process, "*combination of operations*", and the organized result of this combination is standard work.

Standard work is put on display in a place that is easily visible in every workplace in a factory in the form of a standard work chart. It acts as a guide for the supervisor training a new employee. Standard work also acts as a reminder to the veteran employee who had gotten used to doing non-standard work.

When following standard work, any defects will become the seeds for the next improvement. Then a new standard work sheet and a new job instruction will be made.

Since the job instructions and standard work charts are displayed, the manager would be able to tell at a glance whether the people are working correctly, or whether the work guidelines are incomplete.

We can say that following standard work guarantees the quality and determines the cost. Once standard work is decided, we should not just feel at ease to leave things be. Standard work is always dynamic and always contains room for improvement. If we think of it as something perfect, we would not make any progress, and that would be contrary to the creative spirit of Toyota.

Standard Work and Work Standards

Standard work is easy to identify with work standards, but standard work and work standards are two separate things. The term “Work Standards” means all the standards required to carry out the standard work.

For example, during heat treatment, there is the specific treatment temperature of the material, time, coolant type, etc.; also, during machine processing using cutters or tool bits, there is the type, shape, material quality, measurements, cutting conditions, the cutting oil, etc. These are things that were decided based on the economic conditions to produce the required quality. These are work standards.

On the other hand, standard work (despite being a standard for making products) cannot be established if any of these three: the cycle time, the work sequence, or the standard work-in-process is missing.[25]

To safely and inexpensively produce items of good quality, it is necessary that we follow standard work. Including the cycle time is an important feature of standard work and is a point that makes it different from operating standards.

In most companies, the next feature of standard work is developed by a technician who carries out measurements of the work using IE methodologies, and establishes the standard work based on the results. In our company, it is mainly established by the leader.

What the leader deems as "*standard*" become standards. To which the people are instructed, and they are expected to follow. The leader must be capable of teaching[26] the standard work to people at an appropriate speed. That speed must be deemed to be indeed appropriate by a third party.

Standard work is decided by economically combining the number of items required for production, as well as the people and the machines required for making them.

Standard Work and the Supervisor

The supervisor must put effort into constantly creating an atmosphere that emphasizes, "*You must follow standard work*" for everyone in the workplace.

Since it is the responsibility of the supervisor to maintain standard work, they must make people understand that strictly following standard work will lead to meeting quality targets and producing products safely.

The supervisor is familiar with the processes at the workplace where they are responsible for creating a work standard. It is necessary for them to be able to follow the standard work and to make sure the work done this way. They need to investigate and make sure of matters such

[25] In 1955 Shigeo Shingo started teaching what was called the "*P Course*". This program was a basic Industrial Engineering course that covered time studies and layouts; two features seen in the standard work materials. He taught the program nearly 20 years to about 3000 Toyota employees. This program was critical to Toyota's development of the 'standard work' format. The detailing of the work was covered by the TWI Job Instruction skills.

[26] This is a reference to the requirement that a supervisor must be able to use Job Instruction to train people how to properly and safely do a job.

as whether the standard work is being followed strictly, and whether there are any points that are difficult to perform.

Standard work is alive, it is always incomplete and always has tasks that can be improved. For the supervisor who sets the standard work and the people who follow the standards, it is important that both make changes towards continuous improvement. Applying changes to standard work again and again based on their progress.

A supervisor at a workplace where the standard work has not been revised regularly, has proved themselves to be an "*incapable leader*" in terms of continuous improvement.

A supervisor may complain that people do not follow the standard work, but to have them follow it, it is important for them to allow the people, who know best about that work in the workplace, to participate in planning, and listen to their opinions when creating the standard work. This is one way to raise awareness for standard work that the operators can say, "*we made ourselves*".[27]

Implementing standard work is done by following it, and continuous improvement is made through applying alterations to it.

When standard work is observed, if there is an abnormality in the work result, the cause can be easily pursued and the clues for improvement and the location of the problem can be found. The supervisor must never forget that the standard work is one of the primary factors that affect quality.[28]

The format of the various standard documents used in this chapter as examples are focused on those being used in our Honsha Plant.

There are some variations between plants, but their fundamentals are common. Each plant, and each department should apply the standard documents with the format they find appropriate.

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[27] A suggested format is to select two of the most experienced people to assist in making the job breakdown. The supervisor acts more as a facilitator to draw out the knowledge of the job when they are defining the key points and reasons for each key point. After they have developed a job breakdown, the three should practice delivering it as training. Here they will often discover even more details overlooked when they originally created the job breakdown. This step also helps to define how much of the job to teach at a time (bite-sized units).

[28] The Key Points in the job breakdown used for training must clearly define all the activities that must happen to insure the desired outcome to meet quality expectations.

Section 2 - Creating Standard Operating Procedures

Three Elements of Standard Work

When creating standard work, note that *"the standard is something the supervisor establishes themselves."* The supervising leader of an organization or the supervising team leader must fully understand the three components that are required for standard work.

Three elements of standard work are (1) cycle time,[29] (2) work sequence,[30] and (3) standard work-in-process (WIP).[31] If one of these is missing, standard work is not complete.

Cycle time

Cycle time is measured in minutes and seconds within which one car or possibly, one item must be produced, and which will depend on the production quantity and operation time.

To calculate cycle time, divide the required quantity per month by the number of operation days; find the required quantity per day, and the operating time per day.

Required number per day = Required quantity of one month ÷ Operating days

Cycle time = Operating time ÷ Required number per day

Note: When there is a difference in the operation time per day or in the number of shifts, we do the calculations using the hourly schedule instead.

When the cycle time is decided, you decide the work amount of each person in a way that ensures that the work could be completed within this time. We do not plan on what is called a surplus or margin (no planned waiting time).

Standards such as work speed and proficiency are established by the group manager. When a person new to the group becomes able to do the work in a time equal to that of the group leader, this person will be fully qualified.

If you decide the cycle time in this way, individual differences will come up depending on the operators. Because we do not plan in waiting time, everyone will be able to tell if there is unnecessary activity or imbalance and this will lead to improvements. When things are different from the cycle time, it gives us a clue for improvements.

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[29] Velocity or work capacity – the number to make sure that this process can be synchronized with others upstream and downstream to achieve flow.

[30] You must have a job breakdown sheet to train people to the standard. This is part of the Job Instruction program to properly train people to be able to do the task in a defined time, in the desired sequence, and following the desired method.

[31] This is not defined just to limit the inventory, it is defined as a factor necessary for stability to create flow; too little or too much and you do not have flow.

Work Sequence

The sequence of work describes what people are doing when manufacturing something, moving items, loading and unloading the machines, etc. The transition from raw materials into products; It is the order of doing work with the flow of products, not the order in which products flow.

Suppose the work sequence is not clearly defined, we will end up having every individual working to a sequence of their personal preference. Depending on the person, or even if it is the same person, the order of work may differ each time.

If you do not follow the sequence of work, you may forget a process or misplace things for the downstream process, damage the machine, stop the assembly line, or even recall the car in the worst case.

When creating standard work, it is essential for the work sequence to include no unnecessary activity, unevenness, nor unreasonable activity. To clearly understand and grasp the situation, the work is divided into small sections (for training).[32]

For example, it is necessary to clearly show how to use both hands, the position of the feet, how to grasp the work, etc., have the person understand these key points, and standardize it.

The intention of the people who create the standard should clearly express: "*Work should be done like this*." It is necessary to have confidence in the work instructions to quickly and safely make good products.

Standard Work-In-Process (WIP)

Standard WIP refers to work in progress in the process that it is necessary to do the work, including what is mounted on the machine.

The standard work-in-process can vary according to the distribution of the machinery as well as the way work sequence is set. When defining the WIP, it is decided by knowing how many items must be present between the processes, so the capacity is achievable.

For standard WIP, with the sequence of machines where work is performed in the same processing direction, the items mounted on each machine are just enough, and no in-process stock is kept between production processes.

When work sequence is opposite the processing direction, one item would be needed between each process and the following (or two items in case of double mounting).

[32] The Job Instruction training process instructs the supervisor to teach no more than the learner can grasp and to make sure they understand the value of the work they are to be doing.

The standard WIP also includes the number of items required between two processes for quality checks, or when some items must cool down to a certain temperature to perform the following operation, or the number of items required when de-oiling is to be performed.

Creating a Part Specific Capacity Chart

To establish standard work, for every production process, we start by writing down production capacity of the part in the part-specific capacity chart.

In this part-specific capacity chart, we record the process order, the process name, the machine number, the basic time, the time needed for changing cutting tools, the number of items (between tool changes), and the processing capacity.

When preparing for standard work, the part-specific capacity chart acts as a guide for the combination of work.[33]

表 1

部品別能力表

品番 43202 — 36022 　型式 RU, JU, HU 　個数 2 2 2

工順	工程名称	機番	基本時間 手作業時間	自動送時間	完成時間	刃具 交換個数	交換時間	加工能力 (840')	備考
1	両センターもみ	CE−239	08	1 10	1 18	140	1'00"	630ケ	センタードリル
2	外径荒削り	LA−1306	08	1 27	1 35	10	30"	530ケ	チップバイト（インフィード）
						20	30"		〃（〃）
						80	30"		〃（外径）
3	外径中仕上げ削り	LA−1307	08	1 24	1 32	10	30"	548ケ	〃（インフィード）
						20	30"		〃（〃）
4	外径仕上げ削り	LA−1101	10	1 32	1 42	40	30"	488ケ	〃（〃）
						20	30"		〃（外径）
2−1	30φ外径研削	GR−120	(15)	(2 21)	(2 30)	1,500	70'00"	680ケ	9', 6', 2'21"
2−2	〃	GR−121	(12)	(2 21)	(2 27)	1,500	70'00"		6', 6', 2'21"
	（同一工程が2台ある場合）		14						1ヶ当たりの手作業時間を記入 $(\frac{15"+12"}{2}=13.5"\to 14")$
3	ブローチ抜き（2ヶ付け）	BM−131	(09)	(43)	(52)	700	5'00"	1,937ケ	
	（同時加工の場合）		05		26				〃 〃 $(\frac{9"}{2}=4.5"\to 5")$
4	30φ測定（1／5）		(20)						
	（5個に1個測定する場合）		04						〃 〃 $(\frac{20"}{5}=4")$
		合計	28						

34

Order of filling out the part-specific capacity chart.

(1) Process Order - It is the order in which parts are processed according to the production process; number 1, 2, 3 ....

(2) Process Name - The name of the process in which parts will be processed; operations that are carried once every several cycles such as chip removal, or inspections are also listed with their frequency.

[33] This chart can be considered a high-level chart necessary for creating flow in the process and it is targeted towards machining or fabricating processes. The differences between capacity at each step can be seen on a single sheet, as also how many pieces can be process before tooling needs to be changed and highlights the downtime at each tooling change. This chart lists the machines in sequence necessary to make this part.

[34] Similar to Figure 22, page 106 in "*Kanban: Just-in-time at Toyota*"

Notes: ① If there are two or more machines in the same process, they are written separately.

② If a machine takes 2 or 3 parts at a time, it is recorded as "*double mount or triple mount*"

(3) Machine Number - The machine number is written as "CE-239", "LA-1306," "MI-865."

Note: ① When there are two or more machines in a single process, we add a new line and write it in there.

(4) Basic time - We input the following three values: manual labor time, automatic machine time, completion time. In the field for the basic time total, we input the total of the manual time.

(A) Manual Labor Time - The time required for the manual labor performed by the person, such as loading or unloading work on the machine, or feeding is recorded, while omitting the walking time.

(B) Automatic Machine Time - We input the time required for a machine to process the work.

Notes: ① In cases of machine processing, fast feed, automatic return, and auto ejection are also included in the input.

② In cases of presses, automatic welding machines, fixed nut runners, assembly machines, or automatic lubrication devices, we input the time starting from pushing the start-up button until each of them finishes the intended work.

(C) Completion Time - Refers to the time required for a machine (or a process) to finish one part (or two, if it does two at a time); and it is the result of the addition of automatic machine time to manual labor time, we would have the three types that we will explain in the following "*Illustrated time*" part as our models, where it can be one of them, or possibly a combination of the three.

General considerations when inputting basic time:

①Record the time per single item

②When 2 or 3 items are taken at a time, fill in their time in brackets.

③ When two or more machines are used in the same process, the completion time is recorded per machine, and we do not calculate the average completion time of them as a process.

④ Input time in minutes and seconds.

⑤ In cases where 2 or 3 items are done at a time, or when two or more machines are being used within the same process, or in case there are operations that are carried once every several cycles, such as chip removal, or inspection, the sum field is filled using the manual labor time per item.

(D) Time shown - The relationship between manual work time, automatic feed time and completion time is indicated by a line, with manual work time indicated by solid line (━━━) and automatic feed time indicated by dotted line (·········).

(Example) Three basic types - manual work time 30 seconds, automatic feed time 1 minute

(a) ├────┤ .... |

30" 1'

If the operator presses the start button after chucking, the machine will process by automatic feeding, the completion time in this case is 1:30.

30"

(b) ├────┤

| .... |

1 '

In cases such as indexing machines or rotary milling cutters, where work can be loaded/unloaded on a jig, while the work already loaded on another jig is being automatically cut, the completion time would be 1 minute.

20" 10"

(c) ├───┼──┤

| .... |

1 '

When working with grinders, where unloading/loading work is (20 seconds) carried out, and then the grindstone is put against the surface to be processed (10 seconds), the completion time would be 1:20.

Notes: ① In the remarks column, there is no need to write down everything, as only writing things that would not be understood unless illustrated, or those which would be easier to understand when illustrated, would suffice.
② Manual work - Fill in the time (minutes, seconds) for automatic feeding.

(6) Cutting Tools

In the cutting tool column, write the number of items per exchange and the exchange time.

(a) Number of items per exchange - This shows how many items should be processed before we must exchange the cutters or the grindstones, and it is recorded for each cutter/grindstone.

(b) Cutting tool exchange time - This refers to the time required to carry out a single exchange of each of the cutters/grindstones, where we write down the minimum time.

(7) Processing Capacity

This is the number of items made within the set operating time each day and is obtained from dividing the operating time by the completion time.

The general formula: Processing capacity = (operating time - tool replacement total time) / completion time.

Notes: ① Remove any numbers after the decimal point.

② In case two or more machines are within the same process, the calculation is carried out separately, and we record the total number of items made by each

(8) Remarks

Write down any special notes. Example; Illustrations of the basic time, types of tool bits, etc.

(9) Part number – Part name.

We write down the number/name of the part processed.

(10) Model - Number of items

The model of the car that would use the parts, and the number of parts to be used, are written down for each model.

(11) Affiliation – Name

The code number of the division-unit-team is written down, and the name of the author (the name of the leader of both shifts) is written.

(12) Date of creation

If the chart is newly created, we draw a circle around "*new*", when revising we circle "*edit*". We also write down the date.

Note: ① When carrying out a partial alteration, the part to be altered is written in red color. Entries which are no longer needed are canceled with a red line, and the stamp the person who made the correction to that part and fill in the date.

After filling the production capacity chart

Once the part-specific capacity chart is filled, we calculate the cycle time from dividing the number of items required by the operating hours per day and decide the order in which each person will operate within this time.

If part-specific capacity chart is simple, we can establish the order from it without any changes.

If it gets a little complicated, we will lose track of whether a machine's automatic feed is already finished or not, while we are in the middle of deciding on the work sequence.

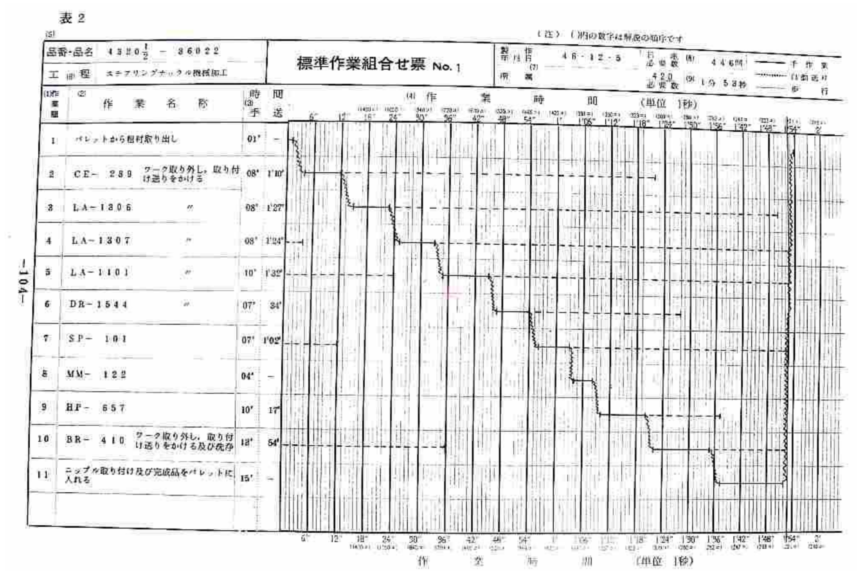
That is where we make it so that we can visually observe the timewise transition, utilizing the "standard work combination chart" as a tool to decide the work sequence.

In the standard work combination chart, we write down the work sequence, work details, work time, etc.

In the work time field, the graduations are in units of 1 second. It is possible to enter work up to two minutes (depending on the form, up to 13 minutes) for one piece.

In case the work time is more than 2 minutes, or if there are many entries, we can add vertical and horizontal lines to keep things in one page.

How to fill the standard work combination chart



[35]

Contents of the standard work combination chart explained.

(1) Work order

The order in which work is performed is represented by 1, 2, 3 ... as numbers.

(2) Operation name

The machine number and the details of manual work are described.

Notes: ① We keep the units of each of these as small as possible.

② In case a single machine takes 2 or 3 items at a time, it is recorded as “double mount or triple mount”

Examples: (a) SP-377 unmount work- mount work -feed. (double mount)

(b) Fit the parent metal into the cylinder block and cap, and so on.

(3) Time (Manual work / automatic feed)

Write down the manual time and the automatic time in the part-specific capacity chart.

(4) Working time

The manual work time is represented by a solid line, and the automatic feeding time is indicated by a dotted line. The walking time to move to the next machine is indicated by a wavy line.

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[35] Similar to Figure 23, page 108 in “*Kanban: Just-in-time at Toyota*”

(5) Part number – Part name

It shows the number/name of the part processed, conforming to the part-specific capacity chart.

(6) Process

This is the general process name, is based on the work name entered in the standard work combination sheet.

(7) Date of creation

Indicate the date of creation of this chart and the name of the creator's department / affiliation / group.

(8) Daily Required Amount

This shows the amount obtained by dividing a month's required amount by the number of operating days.

(9) Cycle time (420[36] / required number)

It is the time obtained by dividing the operating time of the day by the necessary number of the day.

We have explained about the contents of the standard work combination chart. Next, we will explain how to fill it out.

1) Write the cycle time.

From the number of items required in one day, we calculate how many minutes and seconds a single item should be produced and write it down.

(2) Draw a red line at cycle time.

Draw a red line for the cycle time in the operation time scale in the standard work combination chart.

(3) Decide the process scope for each person.

Calculate the total manual labor time in sequence from the part-specific capacity chart, where it would be nearly equal to the cycle time indicated with the red line (the walking time adds up a little more, so keep that into consideration), and then decide how far through the processes can a single person can handle.

(4) Summarize the details of manual labor

In the field of the operation name, each operation's details are summarized and written in one line.

(5) Write down the time in the time field.

Check the manual time and the automatic time in part-specific capacity chart and copy them into the standard work combination chart.

[36] This is their calculated number of work minutes per day after subtracting break and lunch times.

Note: When entering time, among the three fundamental types in the basic time part-specific capacity chart, illustrating cases like (b) and (c) would make the relationship between manual time, automatic time, and completion time easier to understand, and is convenient when making a combination.

(6) Write down the first operation time.

Draw the work sequence in your head, and write down the first operation time, where manual time is drawn with a solid line, while automatic time is drawn with a dotted line.

(7) Decide on the second operation

Consider the work sequence of the second operation. Usually, it would be the operation right below. If there is a distance between machines, where walking would take 3 seconds, draw a diagonal three-second wavy line from the end of the first operation until the center of the following process's field. We continue to the following processes in sequence just like this.

Note: There are cases when one machine is divided into 2 operations, and there are times when these 2 operations are carried out separately, or times when most processes are loaded with 2 items, but one part can only be loaded with one. In these cases, when we try to move ahead to the following process after finishing those 2 operations, or repeating the one-item load process twice, a machine time worth of one operation, (or one item) will turn into waiting time.

In such cases, we need to insert the dotted line while watching out for when the machine work will end. If the lines collide while going back, that would show that the machine work is in progress, meaning that this would turn into waiting time, so we go further down to the next in sequence.

(8) Find out whether the work combination is valid or not.

As we proceed with deciding the operation sequence, the dotted line of machine work would sometimes collide with the red line we drew at the beginning. In that case, the insufficiency in machine work is drawn in a dotted line beginning from the start point. This is to see if the work combination holds true or not. In the case this dotted line collided with the manual work solid line we drew before, this would mean that this combination does not hold true.

(9) Examine the relationship between the scheduled work range and the cycle time.

Once we are finished with illustrating the manual work up to the process we estimated at the beginning, we go back to the first operation. We examine the relationship between the point to which it returned and the red line we drew at the beginning.

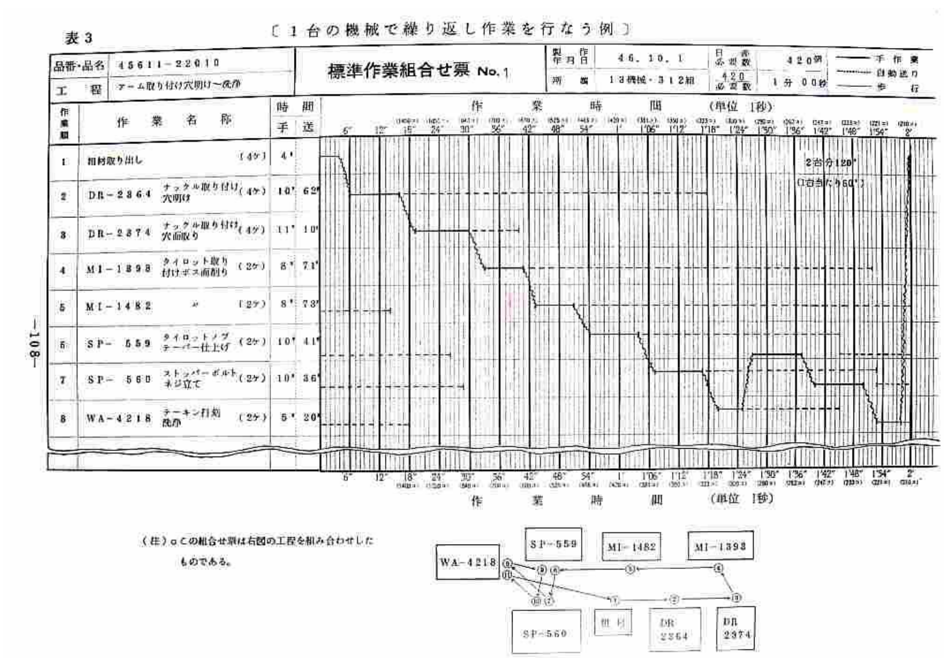
(10) Confirm whether work quantity is reasonable or not.

If the red line and the return point meet, then that would make an appropriate combination. If the manual work ends before the red line, then that would mean the work quantity is less than the time available, and we should investigate whether the person can handle one more machine. If it goes past the red line, we reconsider each process once more to find how we could cut down the extra amount only.

For example, we investigate whether the location of raw materials, or the location of the jigs are appropriate for working easily, or whether they are placed in an easy-to-handle manner or not. We pursue continuous improvement such as whether the spacing between machines is too far, or whether one machine can be made so that it automatically loads/unloads the work. If we reduce the number of machines a person handles right away, we crush the buds of improvement.

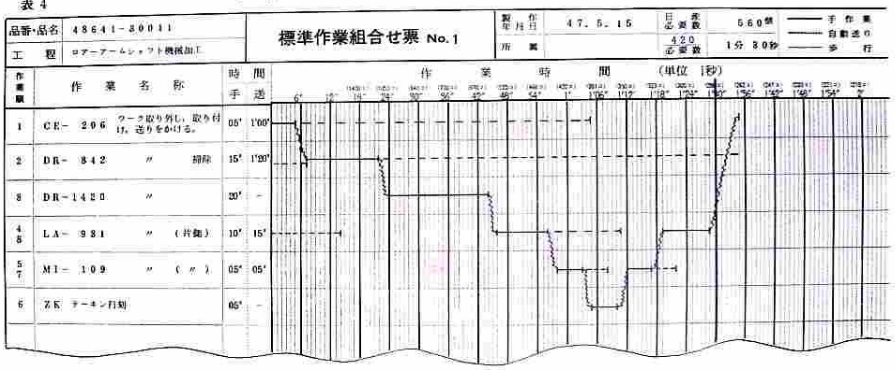
(11) Write down the operation order

Once the combination is finished, we write 1, 2, 3, … etc. in the operation sequence column according to the operation sequence which is based on the final illustration.



〔1台の機械で2つの作業をしている場合の例〕

表 4

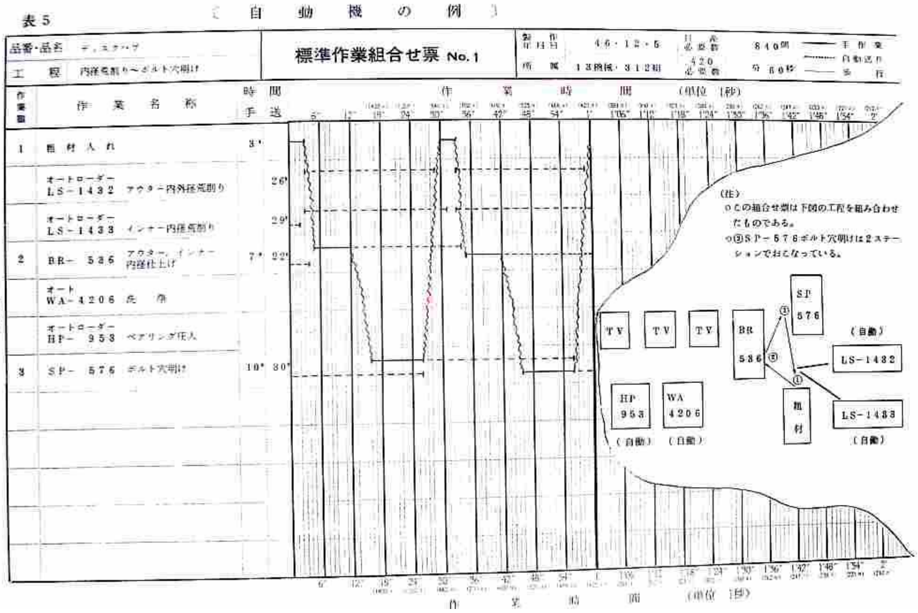


（注）○第2工程のDR－842の時間は、サイクル・タイム（1'30"）より5秒超過する。
したがって、このままでは、時間内に必要数を生産することができないので、ワークの取り付け、取り外しおよび送り時間のいずれかで、短縮するような改善をする必要がある。
○改善により1'30"以内に短縮するまでは、とりあえず不足分を時間外作業でカバーする。

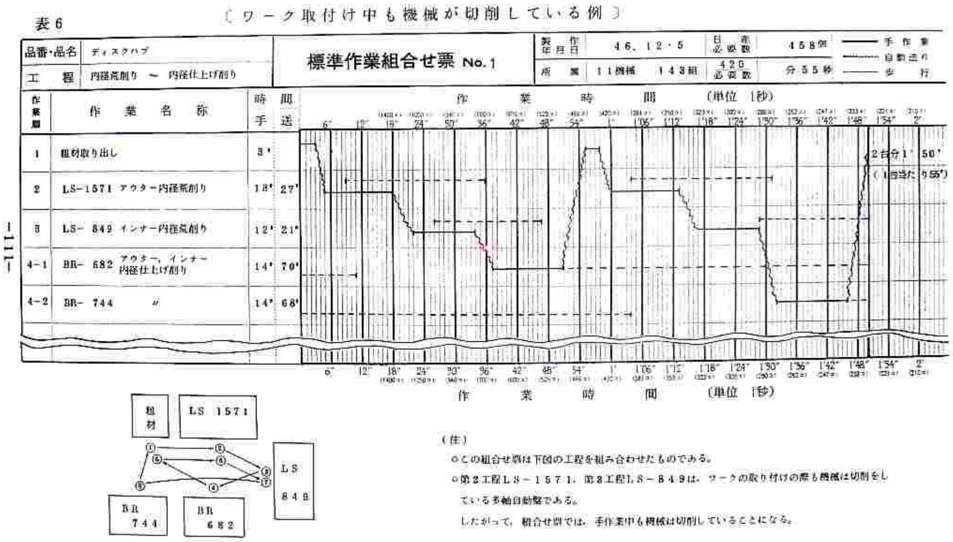
—109—

〔自動機の例〕

表 5



—110—



[37]

Using the standard work combination chart, you should try doing the work. Then confirm whether the work can be accomplished in that order within the cycle time.

Once it can be performed according to the work combination chart, it is important to employ TWI's "*Job Instruction*" (JI) to effectively train the people[38] until they become capable at following the steps and can meet the cycle time.

Combining Equipment Capacity and Work

All the parts making up a car have been completed passing through the hands of many people. If we have parts that are enough to build one car, like one engine, one transmission, one body, etc., we will be able to make one car properly.

For example, a four-cylinder engine is composed of primary parts consisting of a block, crankshaft, camshaft, 4 connecting rods, and 4 pistons. Suppose that the line that manufactures the blocks broke down, and that the production of the blocks is stopped.

What sort of action would be taken by the people who work on the other lines like the crank or the camshaft manufacturing lines? Would they all continue producing their own parts?

Having items up to the defined number stored in the defined place is a good thing; manufacturing even a single extra item, then bringing a box from somewhere or another and filling that box thinking, "thank goodness the in-process stock has increased, with this we are safe…" is unacceptable.

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[37] Similar to Figure 25, page 109 in "*Kanban: Just-in-time at Toyota*"

[38] Job Instruction requires that you create a job breakdown sheet that details the training information before you start training operators.

When assembling one car in the assembly line, if you have parts that are enough to assemble one car, you will be able to assemble it, but even if you have parts that are enough for two cars or even more, they will not be needed at the same time.

This will not contribute to the production in the slightest but will only provide a feeling of relief to the people working in that assembly line, so the next car could also be assembled for sure.

It is good to have the needed things, in the time they are needed, and in the needed amount. Since the assembly line assembles one car at a time, if you match the timing of the line and have parts for only one car ready, this will be enough.

By continuing to do this in the right time, one time after the other, you will be able to steadily assemble a hundred or even a thousand cars per day. This is what it means to provide parts using a conveyor.

When using other transport equipment, depending on the parts, transporting one box, or parts for one car, is uneconomical. That is why, sometimes several items, or possibly several dozens of items, are transported and placed by the line side as a single transport batch.

To deal with such method of transport, it would be good if the preceding production process produced the needed amount of each part.

Organization of the Line

Think about the relationship with equipment capacity; it is desirable if the capacity of equipment organized for production to corresponded for the production amount. Since the demand of the market fluctuates and is difficult to predict, the equipment capacity is often either too much or too little relative to the production amount.

To respond quickly to fluctuations in demand, it is preferable to have a slight excess of equipment capacity. Many factories are often planned to have enough capacity for equipment surplus.

Sometimes there are cases where the equipment capacity does not keep up with the increase in demand, or the machines did not display the expected capacity, or the equipment capacity is low relative to the required production number other reasons.

In summary:

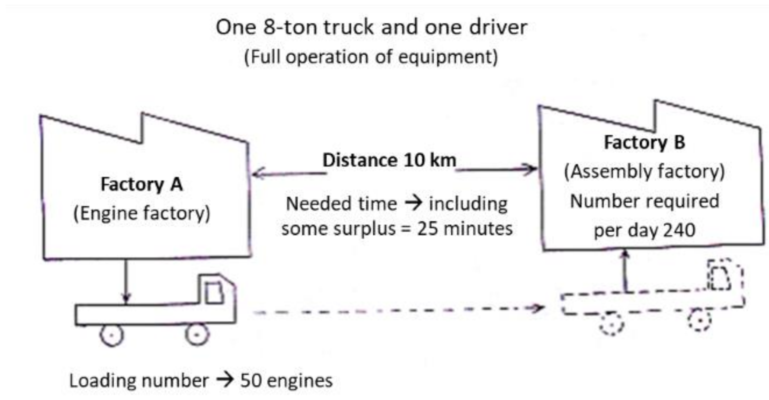
(A) When the equipment capacity is more than the required production number, consideration is given to utilization of facilities to match the required production number, and it is necessary to adjust the number of people.

(B) When the required production number is more than the facility capacity, consider means for improving the capacity of a process that becomes a bottleneck. It is important to make full use of the facilities of this process; to assign people to fully utilize the equipment.

An example, if we consider the truck as machinery, we can clearly understand the relationship between the required number and the labor (when there is surplus in equipment and when there is not).

In the factory, transport was done by one 4-ton truck, but because of lack of capacity that was caused by the increase of the production amount, we compared whether it is better to transport using one 8-ton truck (one costs ¥ 2,930,000), or provide another two 4-ton trucks (one costs ¥ 1,354,000), it will be like this:

In the case of one 8-ton truck, as the required number per day is 240 units and the loading capacity is 50, 240 / 50 units = 4.8 trips. This means 5 round trips are required each day.



Travel time is 25 minutes × 2 (round trip) × 5 trips = 250 minutes.

The time needed for loading/unloading (per day) is:

(a) If one driver does the unloading: 45 minutes × 2 (loading and unloading) × 240 units = 360 minutes.

(b) If at the factory, one unloading person and the driver do the unloading: 30 minutes × 2 (loading and unloading) × 240 units = 240 minutes.

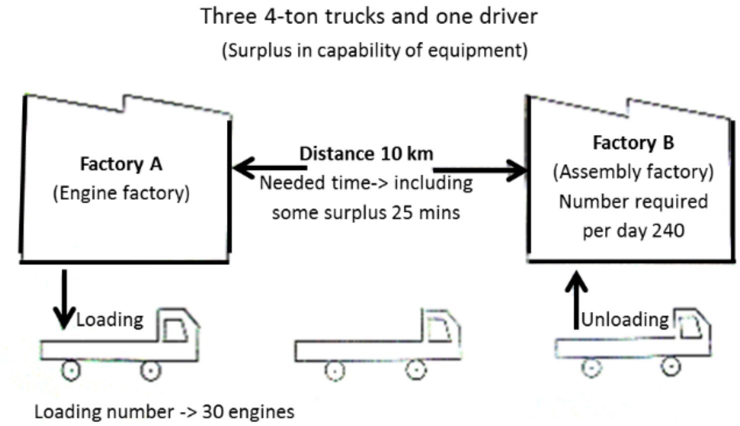
(c) If at the factory, two unloading people and the driver do the unloading: 20 minutes × 2 (loading and unloading) × 240 item = 160 minutes.

The time needed for transport for one day is:

In case of (a): 250 min. journey time + 360 min. loading/unloading time = 610 min.
In case of (b): 250 min. journey time + 240 min. loading/unloading time = 490 min.
In case of (c): 250 min. journey time + 160 min. loading/unloading time = 410 min.

Since there is only one vehicle (no surplus equipment capacity), we must shorten the loading/unloading time as much as possible to fully operate the equipment capacity. If we choose (c), there are 2 unloading people in each place, the time we needed will be 410 minutes.

In case of three 4-ton trucks, the required number per day of 240 units ÷ 30 = 8 trucks; we will need 8 round trips.



Travel time is 25 minutes × 2 (round trip) × 8 trips = 400 minutes. In every loading/unloading location there will be one truck parked, since the driver will change trucks, one loading person in one factory, and one unloading person in the other factory, will be able to load/unload during the journey time while having surplus (during the 50 minutes of the round trip). We will be able to finish the work within the 400 minutes of journey time of the 8 round trips.

Evaluation:

The cost of purchasing one 8-ton truck (¥ 2,930,000) – the cost of purchasing two 4-ton trucks (¥ 2,708,000) = ¥ 222,000

The work time will be shortened by 410 mins – 400 mins = 10 mins/day.

The number of people needed will decrease by two.

The number of lifts will be decreased by two.

The choice of three 4-ton trucks will be more economical.

Combination of Tasks

We mentioned mutual cooperation in Chapter Two. The work must be combined in a way such that the cooperation between every stage can be properly achieved.

This means that you should not strictly set the scope of work of every individual, but make the responsibilities overlap, and make a combination that achieves good teamwork.

For example, if you set the scope of work of every individual, those who are fast at working will keep proceeding with their own work, while goods will pile up like mountains in front of those who are slow. The waiting time will arise for those who are fast, and those who are slow will be in a hurry which may lead to sending defective products to the next stage.

The production capacity will be decided by the number that can be produced by those who are slow at their work. To prevent such shortcomings, you must make the extent of work responsibilities of every individual overlap and create an environment where work can be done easily. (Not the swimming relay, but make it track-and-field overlap).

To create an environment where work could be done easily, you must reduce the distance between the machines as much as possible, since cooperation will be difficult if the distance between every person and the other is too far. You must make it such that all individuals could cooperate at a short distance, and you must avoid work combinations with machine arrangements that are fixed on the abilities of one person. (That is what we call "*small isolated islands*", details in appendix.)

If the idea for the overlap of responsibilities goes well in case a person leaves their work for some reason, or if someone is absent, they will be covered by people from both sides, and even if amount produced in within the designated time is reduced, the needed amount could be secured by extending the time. The effectiveness of this is particularly remarkable in places that have a lot of manual labor like assembly lines.

Section 3 - Preparation of Work Instructions

About Job Instructions

The job breakdown sheet (Job Instruction) sets work procedures in a way that allows work such as operating machinery, changing cutting tools, set-up, processing parts, and assembly to be done based on scientific thinking, *accurately, quickly, easily, yet safely*; the job breakdown sheet is something that is written for every single production process.

The job breakdown sheet takes both validity and specificity into consideration, and specifically describes the important steps that must be followed, the key points, and the reasons why for each key point.

We create the content of the work in the job breakdown sheet according to the work sequence, and we write the important steps and key points required for performing the work in that order. To make things easier to understand, we add sketches and fill in the details. When it comes to key points, we must avoid abstract words; as much as possible we must write in a specific quantitative manner.

Method of filling out work instruction sheet

We shall explain how to write a work instruction sheet.

(1) Operation name

We write down the name of the operation in question.

Example: Exchanging cutting tools, assembly, setup, etc.

(2) Enter the name of the line name processing / assembly line etc.

Example: RU knuckle machining line, 5R engine assembly line etc.

(3) Engineering order, machine number, process name, affiliation name, date created

We write them in accordance with the part-specific capacity chart.

(4) Number

The work sequence is indicated as 1, 2, 3, etc.

(5) Details of the work.

Procedures for proceeding with work, describing each element work in the order of work. Write as simple as possible using a "*noun + verb*" statement; describing "*to do something*".

Note: If measurement by gauge etc. is included, we write that as well.

(6) Key Points

In the key points, there are the three conditions: success/failure, safety, and making work easier; we write the key points needed for people to perform their work accurately, safely, conscientiously, as well as quickly. The key points are about "*How*" the procedures should be performed.

Notes: Three conditions of the key points refer to the following:

① Success/failure: Something that controls whether the work becomes complete or fails, something related to quality.

② Safety: A behavior that could lead to injury while performing work.

③ Making work easier: Something that makes work easier to perform, things such as sense, tips, skills, tricks, or some special knowledge.

(7) Sketches

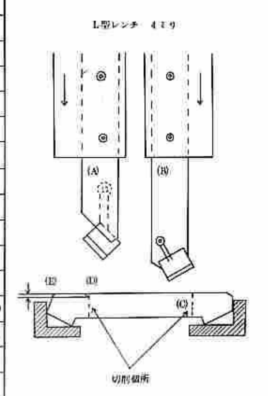
If we express the operation sequence or the key points with words alone, there will some cases where the explanation will end up being insufficient. We make simple illustrations of the jigs, the location of the work, how it should be placed, how it should be mounted, and other things needed to perform a job.

表 7　　注 （）内の数字は解説の順序　　新改 46年 12月 5日 作成　　全 ページ中 ページ

課長	工長	組長	(1) 刃具取替え 作業要領書	(2) ライン名	RS系リングギヤー加工ライン		所属	氏名
				工順	4	(3) 機番 LS−494		
				工程名	内径中仕上げ 面取り			

(4) No.	(5) 作業内容	(6) 急所（正否・安全・やり易く）
1	チップ締め付けボルトをゆるめる。	ブレーカーを左手でささえながら
		4ミリのL型レンチで
2	チップをはずす。	
3	チップおよびホルダーの取り付け面を清掃する。	
4	新しいチップブレーカーを取り付ける。	奥まで
5	チップブレーカーの締め付けボルトをしめる。	チップをおさえながら、固く
6	(B)の取り外し、取り付けは 1・2と同じ要領でおこなう。	(C)の中仕上げ削り内径
		ねらい寸法 107.56〜58 ①チェック 107.66〜68 ②チェック
		(D)の面取り45°×2.8c（焼入研磨後の完成2.5c）
		(E)の面の深さ（内径面取り）1.8〜1.9ミリに
		内径の調整はダイヤルを取り付けて
		ホルダーを微動させるように
		チップの取替 (A)240ケ (B)240ケ

(7) 見取図



—120— [39]

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[39] Similar to Figure 25, page 110 in "*Kanban: Just-in-time at Toyota*"

Section 4 - Preparation of Work Instruction Manual

Work Instruction Manual

Work instruction sheets are created based on the part-specific capacity chart and the work combination chart.

It states the details of work meant for a single person to meet the production amount in each line, as well as the main points regarding safety and quality, in accordance with the work sequence.

The work instruction manual illustrates the machine placement for one person's work, the cycle time, the work sequence, the standard work-in-process, as well as where and how quality checks should be performed. We define fundamentals like the main safety points.

We must ensure that when the people follow the instructions of the work instruction manual, they would be able to work reliably, quickly, and safely.[40]

Normally, the machine location illustrations in there are drawn in A3 size paper, then we input these entries: work sequence, standard work-in-process, cycle time, the net time, and quality checks.

We put it in a case and display it in machine processing lines or an assembly lines in the work site, calling it "*the standard work chart*." By displaying the "standard work chart", the guidance of the supervisor, which defines: "*Work should be done like this*", becomes visual.

A supervisor has many people and remembering the work they have assigned to each individual one of them would be extremely difficult. When they look at the "s*tandard work chart*", they will be able to confirm whether people are performing their work correctly as they had been instructed. They would become able to pursue the possibility of discovering any new waste or faults in that standard work itself.

Using the "*standard work chart*," a manager would be able to evaluate the capabilities of the supervisor, as well as investigate whether the people are performing their work correctly.

When a person makes a mistake during work, it would be possible to point out that mistake based on the standard work and warn them; "*management at a glance*" would be possible.

How to write the work instruction

Next, the method of filling in the work instruction will be explained.

(1) Part number/part name
   Fill in according to the part-specific capacity chart.

[40] The 'reliably, quickly and safely' requirement is a basic standard of Job Instruction breakdown sheets. These are the foundation to building standard work.

(2) Required amount/Classification number

In the required production amount field, we input the amount required per day, according to the work combination chart. The classification number refers to the number of people when there are multiple people in a single line.

(3) Affiliation/name

Fill in according to the part-specific capacity chart.

(4) Number

The work sequence is written as in 1, 2, 3…

(5) Operation details

The contents of the operation are written in the order in which they are carried out, according to the standard work combination chart.

Notes: ① In the case of machine processing, we must make sure to write the machine number, and fill in the details of the operation such as loading, unloading, and feeding materials. When writing, we can keep the expressions as simple as “CE-239 unload/load/feed materials”. In the cases of assembly and final assembly lines, we write the operation contents in detail, as in “Insert mast jacket and tighten clamp.”

② The operation details to be written in the work instructions are usually shown by machine numbers and process names within the “work area” of a single person.

(6) Quality

(a) Checks - write the frequency by which the quality of processed or assembled parts is checked, how often do we check an item (or perform one check).

Examples: (This is in the normal operation details)

1/1 – The check is performed every cycle.

1/10 – One item of every ten items is checked.

1/H – One item is checked every hour.

2/Shift – Two checks per shift.

1/D – One check per day.

(b) Gauges - write the type of measuring instruments (gauges) should be used to check the part.

Examples: C ・・・・Check using a C gauge.

Vernier Caliper・・・・ Measure using Vernier Caliper

LF ・・・・Check using an LF gauge.

Visual ・・・ Check visually.

(7) Key Points

Write the key points required to produce items of good quality in an accurate, quick, safe, and earnest manner (Corresponding to the work instructions).

(8) Net time

It shows the time required for carrying out each operation (the time required for each step) and is obtained from the sum of the manual time in the part-specific capacity chart, and the walking time.

Notes: ① Walking times includes moving on to the next step in the work sequence.

② Operations such as measurements or cutting tool exchanges, which are carried out once every several cycles, are not included in the net time.

Once we are finished with writing the work instructions, the contents of the illustration in the illustration field in the right are copied to the standard work chart.

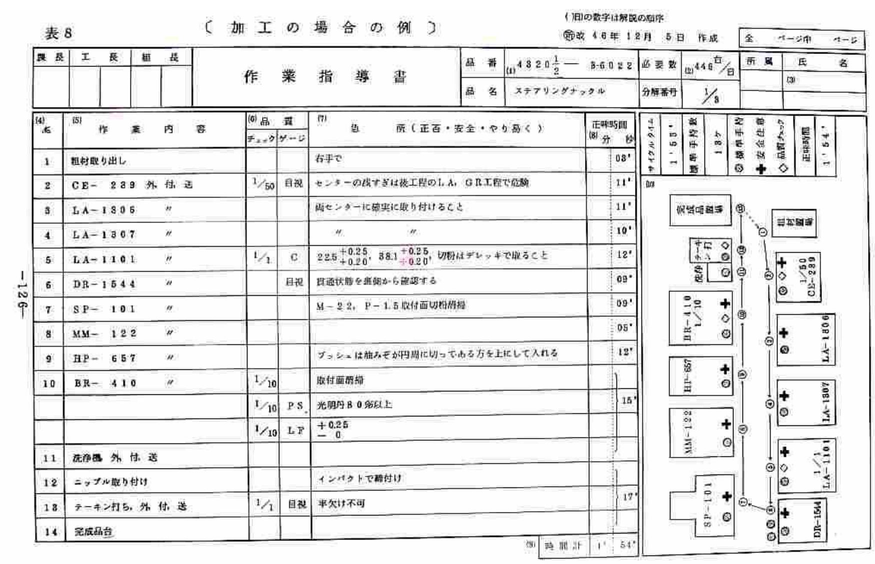

表 8 〔 加 工 の 場 合 の 例 〕

作 業 指 導 書 — 品番 4320½ — 3-6022 — 品名 ステアリングナックル — 分解番号 1/3

№	作業内容	品質 チェック	品質 ゲージ	急所（正否・安全・やり易く）	正味時間 分 秒
1	粗材取り出し			右手で	03'
2	CE- 239 外 付 送	1/50	目視	センターの浅すぎは後工程のL.A、G.R工程で危険	11'
3	LA-1306 〃			両センターに確実に取り付けること	11'
4	LA-1307 〃			〃 〃	10'
5	LA-1101 〃	1/1	C	$22.5^{+0.25}_{+0.20}$, $38.1^{+0.25}_{+0.20}$, 切粉はデレッキで取ること	12'
6	DR-1544 〃		目視	貫通状態を裏側から確認する	09'
7	SP- 101 〃			M-22, P-1.5 取付面切粉清掃	09'
8	MM- 122 〃				05'
9	HP- 657 〃			ブッシュは油みぞが円周に切ってある方を上にして入れる	12'
10	BR- 410 〃	1/10		取付面清掃	15'
		1/10	P.S.	光明丹80%以上	
		1/10	L.P	+0.25 −0	
11	洗浄機 外 付 送				
12	ニップル取り付け			インパクトで締付け	17'
13	テーキン打ち、外 付 送	1/1	目視	半欠け不可	
14	完成品台				
				時間計	1' 54'

41

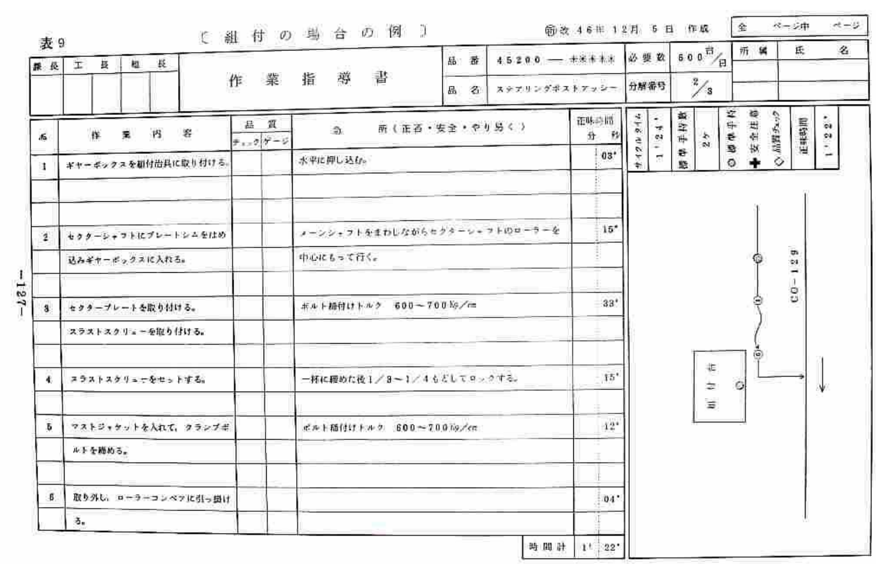

表 9 〔 組 付 の 場 合 の 例 〕

作 業 指 導 書 — 品番 45200 — ＊＊＊＊＊ — 品名 ステアリングポストアッシー — 分解番号 2/3

№	作業内容	品質 チェック	品質 ゲージ	急所（正否・安全・やり易く）	正味時間 分 秒
1	ギヤーボックスを組付治具に取り付ける。			水平に押し込む。	03'
2	セクターシャフトにプレートシムをはめ込みギヤーボックスに入れる。			メーンシャフトをまわしながらセクターシャフトのローラーを中心にもって行く。	15'
3	セクタープレートを取り付ける。スラストスクリューを取り付ける。			ボルト締付けトルク 600〜700 kg/cm	33'
4	スラストスクリューをセットする。			一杯に締めた後1/8〜1/4もどしてロックする。	15'
5	マストジャケットを入れて、クランプボルトを締める。			ボルト締付けトルク 600〜700 kg/cm	12'
6	取り外し、ローラーコンベアに引っ掛ける。				04'
				時間計	1' 22'

42

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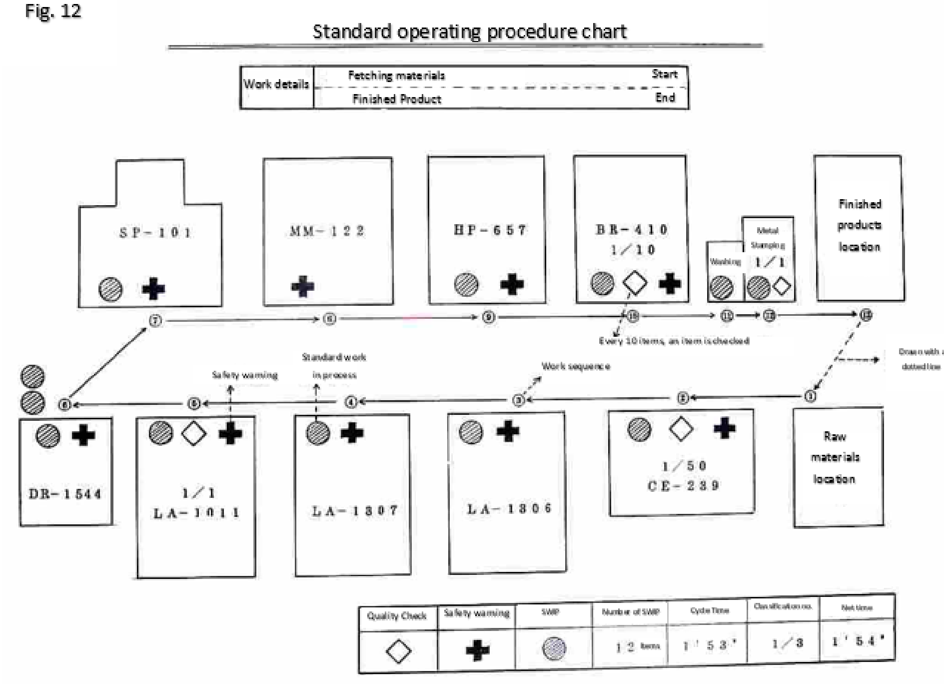
[41] Similar to Figure 26, page 112 in “*Kanban: Just-in-time at Toyota*”

[42] Similar to Figure 27, page 113 in “*Kanban: Just-in-time at Toyota*”

Fig. 12



[43]

[43] Similar to Figure 28, page 114 in "*Kanban: Just-in-time at Toyota*"

Section 5 - Quality Check Table

The quality check table is something that must be incorporated in the work instructions. The purpose of checking the quality of the parts of "∇ S" (important safety parts) and the parts judged to be particularly important in the workplace; for what purpose, where, who, how. We also write about the exchange of cutting tools that is in the part-specific capacity chart and display it in the actual workplace like the standard work sheet.

We will explain about the entries and the contents to be written.

(1) Part number and name.
Write them following the part-specific capacity chart.

(2) Machine number and process name
Write them conforming to the work instruction manual.

(3) Write which portion of the part we are checking (what).

(4) Write which measuring instruments we are going to use for the checks (how).
For example, the type of gauges.

(5) Setting time and work start
Write who will check the setting time, the work starts and how will they do this.
Example: □cont2……The team leader checks two in a row.

(6) Sampling
Write how sampling checks are going to be performed.
Example: △1/10……The person takes one out of every ten and performs a check.

(7) Replacement of cutting tools
Write who will exchange the cutting tools and how frequently they are changed.
Example: 50/□…… The team leader changes the cutting tools once every 50 items.

(8) Goal
Write the target quality which allows us to send the items to the following process with confidence.

(9) Illustrate the location of the quality check in an easy-to-understand manner.

(10) Why?
Write about the purpose; what reasons we are performing quality checks. In some cases, this entry is considered and then written before anything else.

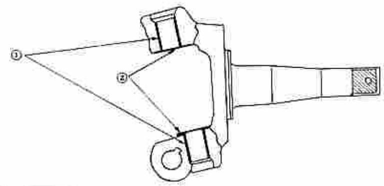
表１０

（ ）印の数字は解説の順序

(1) 品　番	４３２０１－３６０２１	重要品質チェック表				機　番	ＢＲ－４１０	
品　名	ステアリングナックル					工程名	(2) ブッシュ内径仕上削	

	(3) どこを	(4) なにで	(5) セッチング時と作業始 だれが	いつ	(6) 抜取 だれが	いつ	(7) 刃具交換 頻度／だれ	(8) ねらい
S ①	キングピン孔	４Ｐ	□	連　２	△	１／２０	５０／□	通し検範 ２５φ ＋０.０２８ －０.００７
S ②	当たり面（角度）	１３Ｐ	□	連　２	□	１／２０	５０／□	当たり面　光明丹 ８０％以上
				連続してチェックする		２０ケに１ケ抜取りチェックする		

(9)



△	作業者
□	班　長

(10) どうして：① キングピン焼付防止　② ハンドルの安定を計る

Section 6 - Procedure of work based on standard work

It is important that the supervisor ensures that people adhere to standard work. No matter how good standard work is, if the people do not follow it, the stability of the production process will be lost, the supervisor will have their hands full with accident countermeasures or defective -product countermeasures. This leads to a lot of unnecessary activity.

To have the people understand, as well as follow standard work, it is necessary that the supervisor first sufficiently master it. And perform the standard work thoroughly so they can teach people, so they can grasp it.

Explaining the *reasons why*[44] the standard operation procedure must be followed, teaching what might happen if it is not followed, and motivating people to produce good products as well the responsibility for the quality of the product, and similar attitudes must be developed.

The supervisor should check the results when implementing standard work, and when there are abnormalities. They must thoroughly track the root cause and work out appropriate countermeasures.

If standard work is not followed, we must pursue the reasons for it not being followed, and then change the standard to one that can be easily followed by anyone.

When standard work is observed, and an abnormality occurs, thoroughly pursue the cause. If you find that there are inadequacies in the standard work[45] itself, it is important that you correct it promptly and thoroughly correct all reasons why.

The supervisor must have the attitude to think and say things based on facts. That is why checking how the standard work is done, and practical guidance at the actual workplace must be performed. The supervisor routinely visits the workplace and checks the actual situation, such as whether the person is working according to standard work, and whether they grasp the key points sufficiently. It is important that they grasp the actual situation and can deliver practical guidance on how the work should be done in this situation. In teaching, it is important to make effective use of TWI's Job Instruction method (JI).

We cannot say that "*There is no room for improvement as the existing standard work is the one best way*." Standard Work is alive, it is always incomplete. That is why the supervisor must observe where the defect points[46] are in standard work, and they must not overlook even the slightest abnormality.

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[44] The supervisor uses Job Instruction's job breakdown sheet to teach the job. This format consists of the Important Steps, Key Points for each step as needed and Reasons Why for every Key Point. This manual assumes you are familiar with Job Instruction.

[45] Are any 'key points' missing or incorrect in the work instructions?

[46] These are Safety, Quality and Productivity issues. Failure to follow Key Points can be a reason for the failure, as well as missing Key Points that have not been taught.

Standard work is the center of continuous improvement.[47] Standard work is not something about which you can say "*Now we are good enough*" after you establish it. Standard work is something that was created by accumulating improvements. We must think that the standards we currently have are full of unnecessary activities, and we must constantly create new standards by continuous improvement.

The world keeps advancing and new methods keep coming into existence. If you do nothing, you will be restricted to maintaining your status quo. If we suppose the existence of workplaces where the standard work never changes, no matter how much time passes, or workplaces that are sufficiently satisfied by keeping their status quo as they have done all the improvements they could do, and now believe that they have no problems; those workplaces will return to the old ways.

A supervisor must always perform continuous improvement proactively, as continuing to improve standard work is the mission of the supervisor of the actual workplace.

[47] "*If there is no standard, there can be no improvement*." Taiichi Ohno

Chapter 4 - Kanban System

Section 1 - About Kanban

The Birth of KANBAN

Our company's "*Kanban System*" is the fruit of the knowledge gained in the production workplace, is something original, and is one of our company's symbols that we take pride in. The Kanban System is also referred to as the Supermarket System; it was invented by taking supermarkets as a hint.[48]

As a method to make use of the supermarket system, we used a signal which shows the part number and other information important when starting production. That is how we started calling this production system the "*Kanban System*".

This system started being used officially around August 1963. After undergoing many improvements in a part of the Honsha Plant, the extent of its utilization gradually started expanding, and it became implemented in all our factories.

A supermarket is a market which can obtain the required products, in the required time, and in the required amounts, depending on the customers.

This stems from the idea that customers do not have to buy any goods they find unnecessary, while the market has the goods prepared so that customers can come and buy whatever they want at any time.

Furiuri Peddler

The supermarket system is more rational than conventional Japanese marketing techniques such as "*Toyama nonprescription medicine*"[49], "Door-to-door merchants," and "*Furiuri Peddlers*"[50] in the sense of how it eliminates unnecessary activity on the seller's side (not having to carry goods they do not know when they might sell), and on the

[48] The goal of a 'Kanban System' is to replicate a virtual conveyor. It is a signal and the minimum signal information needed is "what must you know". The next level is "what should you know to make the communication easier or more obvious" (like location of sender and receiver, etc.).
[49] Toyama nonprescription medicine is a sales technique common among medicine manufacturers in Toyama prefecture in Japan, with a history of well over 300 years.
[50] Furiuri peddlers (Literally: Swinging sellers), the term refers to street merchants who carried items hanging from a pole, hawking them in the streets.

buyer's side (avoiding mistakenly buying things they do not need). The application of this concept to the production method is our supermarket system.

By considering the market as the preceding process, and the customer as the following process; the customer goes to the preceding process, which is the market, to take the required product, at the required time, and in the required amount; while the preceding process must replenish an amount equal to the demand of the following process.

When supplying the following process, there is something that must be taken into consideration. If we look at it from the point of view of the customer, which is the following process; we find that they want their required item to have the highest possible quality, yet the lowest possible price.

The production department must produce and provide a supply of high quality items with the lowest possible price to respond to the customer's needs, otherwise it would end up losing the market.

Cost reduction routine eliminates freeloading activities [51]

How can we make it as inexpensively as possible? Consider this: What kind of work creates the value of the product called a car?

By observing the work of the people around us, there would be people who purchase the parts and the raw materials needed to produce a car, process these materials, transport them, and store them, people who assemble all these parts into a complete car, as well as people who design cars, and keep production plans proceeding smoothly. We carry out our corporate activities by producing the merchandise called "*a car*" by having many people take their share of work in various fields.

As we must create products called automobiles, it is people who are directly engaged in the work of manufacturing automobiles, which directly produce the motor vehicle.

Are those who are not engaged in direct work unnecessary? People who purchase materials, parts, and design vehicles are also necessary to produce cars. There is a difference in the content of the work of people directly building the car.

There is a possibility that there are some freeloaders among them. We can say that there is a high risk that the work of such people is unnecessary activity.

When thinking of it that way, we find that we must proactively find the unnecessary activity in management and back-office departments, which are indirectly connected to the value of

[51] This was a difficult section to translate as the direct translation would be parasite or freeloader. The goal in the questioning is to have you consider whether the off-line activities are value adding, more than if the person is a parasite or freeloader.

the product, and make efforts particularly dedicated to eliminating these unnecessary activities.

When looking from the perspective of lowering cost, it is important to get rid all unnecessary expenses for making the product called "*a car*".

That is where it becomes essential for everyone in management and the back-office departments to ask themselves "*Could it possibly be that we are doing unnecessary activities?*" "*Let us do work that has actual value, and will bring profit*," and aim to perform work they can confidently deem as "*not unnecessary activity*."

What we should be aware of here, is the fact that unnecessary activity can exist in the management and back-office departments, as easily as in the work of the people who directly produce the value.

There are many cases when all the work concerning a certain matter is unnecessary activity. We should keep in mind that unnecessary activity does not only include people.

For example, if there is a large storehouse which always contains the same quantity of the same parts or raw materials; we can say that those parts or raw materials, as well as the storehouse that contains them, are something we may not need at all. If we have some wonderful equipment that is not being used half a day, such equipment is also freeloading.

The cost reduction we aim for is about eliminating the unnecessary activity we have described thus far. The real importance lies in getting rid of all unnecessary activity. For instance, in the case of the equipment not being for half a day, if we were to operate it at its fullest to get rid of the unnecessary activity, producing too many unnecessary parts, then everything required starting from the man-hours and power costs, all the way to the raw materials, the parts, and the storehouses will turn into a flood of unnecessary activity, resulting in an increase in cost.[52]

[52] Toyota developed a thinking process described as "*right sizing*" as a countermeasure to having equipment with excess capacity. Sometimes this is much smaller stock equipment that has been modified to the specific process need so it operates fully to match the process consumption of the following process.

If we attempt to eliminate an unnecessary activity in such manner, but end up bringing about more unnecessary activities, then we would not be making any progress.

It is essential for us to keep our eyes wide open and get rid of all unnecessary activity that we have described so far. In that sense, we can say that "*Cost reduction routine means, unnecessary activity elimination routine*."

The First Step of the Endangered Movement Management [53]

We have come to understand that eliminating unnecessary activity is the most effective way to reduce cost. That would mean that cost reduction routine begins from finding out the unnecessary activity first. Is there any good way to find the unnecessary activity?

Under normal circumstances, these are hidden somewhere among the personnel, storehouses, raw materials, and equipment, so it is difficult be recognized. These parasitic activities exist in the form of unnecessary activity (*Muda*), unevenness (*Mura*), or overburden (*Muri*), i.e. the 3M's. If we were to try to find these under normal circumstances, it would likely be rather impossible without an expert.

If we turn cost reduction routine into a job for only some experts, then it goes beyond saying that we would not get much of an effect. This routine is something that every employee should be able to carry out, so it is necessary to keep this easily discoverable for everyone.

What should be done to create such an environment? The first step is to clearly define the standard work.

We can agree that not having standard work clearly defined means that people will have different ways of performing work, making it extremely difficult to discover the unnecessary activity. The first step towards finding unnecessary activity begins from setting the standard work.

The second step is making sure that the standard work is followed. If we define standard work and the people do not follow it, it is about the same as if it had never been defined. We can only say that the standard work is defined when everybody is following it. Defining standard work and having it followed a difficult task.

If standard work is not carried out thoroughly, it would be impossible for everyone to easily spot unnecessary activities.

We should make standard work that is easy for anybody to follow, and easy for anybody to tell whether it is being followed. (For details, refer to Chapter 3: Standard Work)

It is important for us to seek this condition to judge whether the standard work is good or not. When we make such good standard work, and make sure it is followed, will we be able to see

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[53] Removing unnecessary activity combined with management at a glance.

the unnecessary activity, unevenness, and overburden hidden among personnel, storehouses, parts, raw materials, and equipment without difficulty.

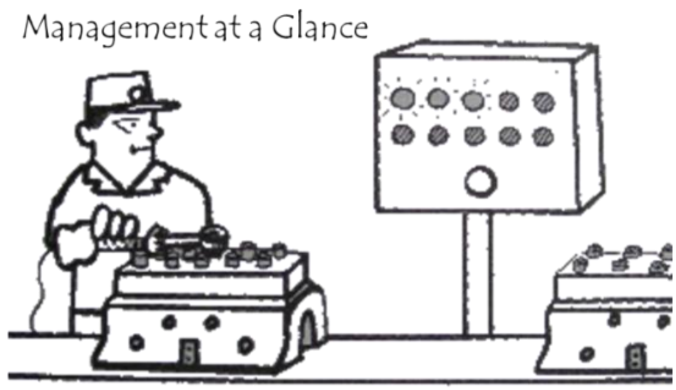
For example, if part A is lot production and 200 pieces are finished when finished goods stock is 100 pieces, put the finished product in a special box containing 50 pieces. When we have 2 boxes left, we start producing until we get 4 complete boxes.

If things are set up like this, the standard work would be comparatively easier to follow than in the case where we just stack up finished products one by one. It becomes easier for the supervisor to tell whether the people are following the standard.

If we take this a step further by setting a rule of placing the signal near the 3rd box, we will be able to tell when to start producing without having to check inventory. Standard work becomes even easier to follow. Once we do that, we will become able to see whether the minimum inventory of 100 items is too much, and whether we need to produce 200 items.

If 1 of the 2 boxes always remains even after we are finished preparing the items, that would mean that this box of inventory can be considered an unnecessary activity, so we should get rid of it and lower our inventory to 1 box.

From what we have figured out in the example above, if we have good standard work and thoroughly implement it, the problematic points would take shape spontaneously, and unnecessary activities will become evident. It would become easy to discover clues for improvements.



For us to manage the workplace smoothly, a management system where you can tell what is going on by looking with your eyes—that is to say, "*management at a glance*"—is important.

"Kanban" is an important visual management tool

Our company has a distinctive method for managing the workplace. Visual management has been strongly advanced unparalleled to other companies. Kanban has appeared as an important tool for visual management. An important way to evaluate Kanban is to be fully aware that Kanban is a tool for managing the workplace.

The Kanban should not be evaluated as a mere tool for managing our parts inventory or production or giving transport instructions. By using Kanban as a tool, the circle of management of the workplace will be able to run very smoothly.

We must focus our evaluation on how it can raise the effectiveness of the elimination of unnecessary activities. Everyone is fully aware that it is important for management and supervisors of the workplace to successfully manage the management circle. It is necessary for us to recognize the importance of effectively managing kanbans.

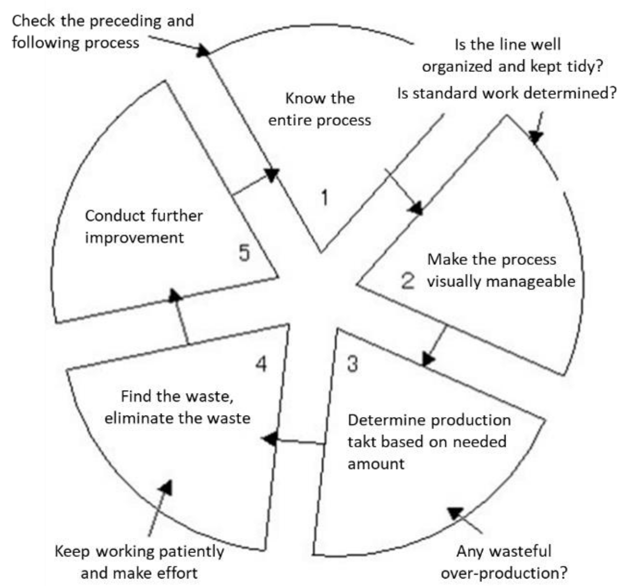
Section 2 – KANBAN Thinking

We believe we have come to sufficiently understand the importance of Kanban as a tool to manage the workplace. Next, the importance of skillfully utilizing Kanbans will arise. We need to fully understand the core ideas of Kanban, Kanban thinking.[54]

Thorough Observation of Workplace

To proceed with improvements or to standardize work, it is essential to sufficiently observe the workplace to fully grasp and understand the situation. Are these essentials being followed?

When investigating problems in the workplace, we find things that indicate that the supervisors and the staff are "*making people do work like this*" are not being followed, and the things that indicate that "there is a problem here" are not actually referring to problems, while problems lie in completely different places.



With things like this, it is nearly impossible to get the management circle going around well. Why is something like this happening? Are the supervisors and the staff not watching the workplace? Of course, that is not the case.

The problem is, even though they believe that they are observing it, what they are doing is far from enough. It can be said that the problems lie in their observation method.

First, there is a problem with the attitude of observation.

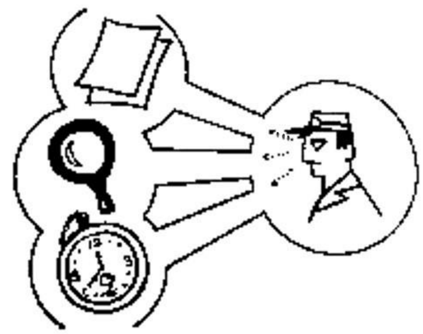
When people have accumulated experience, they tend to look at things with what we call "*bias*." "*It's been like this up till now, so it will probably continue like this*." When they look at

[54] The objective of the kanban system is to create a virtual conveyor between disconnected parts (producing machines, lines, work cells) of the product flow.

a problem while thinking this way, they end up seeing what they expect. And we do not observe correctly.

It is important to have the attitude of constantly observing without any bias, as if you were a blank piece of paper.

Second, the fact that they tend to limit it to a superficial observation.



As in the first case, people who have accumulated experience often feel like they have immediately figured out where the problem lies with brief observation; but the observation should never stop at that point.

The root cause is hiding behind the problems that make you feel like you have got it all figured out with just little observation. Even if you think that you have found where the problem is, it is important to reconsider things while thinking "*No, wait. The problem must be hidden somewhere much deeper*," and continue to observe much more persistently.

Third, is the "*time allowed to observe is too short*."

If a problem occurs in the workplace, we often say "*stay there and keep observing for about half a day.*" If enough time was dedicated to observation, the root cause of the problems would become visible and we would find a countermeasure.

Saying something like "*I am too busy, so I really cannot put that much time into it*" is nothing but an excuse. We are busy because we have so many problems. This is the very reason why we must stay and continue observing for about half a day and find a correct countermeasure.

We must observe with an approach aiming to find the real truths hiding behind facts. Such thorough observation is hardly carried out at all. Standard work that was created based on insufficient observation will be difficult to follow because of the emergence of overburden[55] that does not fit with the actual state of the workplace.

On the other hand, if it is an excellent workplace, measures for improvement are constantly being sought.

Since the problems are changing from moment to moment, it is possible to grasp the problem root cause without mistake by observing sufficiently without bias at the workplace.

[55] Operators are struggling to do 'work-arounds' to cope with the variances (problems) and still meet production expectations.

The cornerstone of managing the workplace is sufficiently observing the ever-changing workplace with the thinking we mentioned. With this thinking, good standard work will be developed, from which visual management system will be formed.

A foundation for effectively utilizing Kanban will be created. The thinking of observing the workplace thoroughly is the most premise for those who intend to operate Kanban correctly.

Pursuit of rationalization and respect for people

To keep the management circle going smoothly and to eliminate unnecessary activity, the first step is standardization that allows you to figure out things at a glance, and that is easy to follow.

For that, we must thoroughly eliminate all the deterring factors. To do so, efforts to simplify are important.

Among the operations in the workplace, there are ones that seem complicated and impossible to untangle at first glance, but even if that is the case, giving up right away is not considered. It is very important to have the persistence to investigate the factors giving rise to complexity and break down complex operations into simpler ones.

Next, we need to make effort towards removing exceptions. For example, to cover up problems like machines breaking down frequently or defective products showing up again and again, we end up making people do non-standardized work, ultimately becoming the reason for the failure to follow standard work.

We must constantly eliminate exceptions to stabilize quantity and quality, it is important to make effort towards eliminating trouble. This effort is the attitude of eliminating unnecessary activities, unevenness and overburden; the pursuit of rationalization.

Because of pursuing such rationalization, the work itself becomes monotonous and simplified. If we do not think of a countermeasure for this, it would eventually lead to alienation in the workplace. It is a fact that this is emerging as a real problem in the mass production industry like the automobile industry.

The pursuit of rationalization and respect for people must be compatible with each other. It is the thinking of the Kanban system, a basic idea in our company. The reason for this is that if we keep the workplace where it can be managed visually, it also means that everyone working there would be able to spot problems or improvements, it would be easy to spot unnecessary activities.

Even if the work itself is monotonous, everyone can participate in improvement activities through finding unnecessary activity. They will be aware that even they can participate in making the workplace better. Being able to feel the sense of accomplishment for an improvement achieved through one’s help, amounts to the restoration of respect for people in the business field.

What really matters is to create an environment in the workplace, which encourages everyone to participate in these activities. Those utilizing Kanban must put special efforts into creating an environment where everyone can participate in removing unnecessary activities, as well as seeking the compatibility of pursuing rationalization and respect for people.

Continuous efforts towards improvement

What is the essence of the improvement thinking? It is the attitude of eliminating unnecessary activity.

The "*thorough observation*" and "*pursuit of rationalization*" is our foundation. The house called "*Continuous Improvements*" (Kaizen) must be built after firmly establishing this foundation.

The basis of improvement activities is said to be the attitude of taking a scientific approach. We will be explaining what this means.

First, to find problem points, we use 5W 1H, we repeat the question "*why*" 5 times; and that is how our company deploys its scientific approach manner. The questioning method called "5W1H" refers to asking the questions "*Why? What? Where? When? Who? How?*" while being in doubt.[56]

There are many cases when questioning ends with only superficial problem discovery and finding the more fundamental problem is difficult.

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[56] It is ironic that Toyota forgot the source of the 5W 1H method so quickly. The need for Industrial Engineers had them supersede the Job Methods improvement process with IE tools starting in 1955. The Job Methods set of questions is for challenging to develop better ways of doing things. The 5-Whys questioning sequence has a different purpose, that of digging down to discover the root cause of a problem.

For example, assume that a machine is not working.

"Why did it stop?"
"Because the switch stopped working."

"Why did it stop working?"
"Because there is oil in the switch case."

"Why is there oil in there?"
"Because the lubricant pipe passes through the switch case, and its joint is leaking."

"Why is it leaking?" …

"Why does the pipe pass through the switch case?" …

Repeating the question "*why*?" is essential. Once we do this, we will get the root cause of the problem to surface. Then we will be able to take a fundamental countermeasure to prevent its recurrence.

In this example, if we go with only a single why, we can come up with the countermeasure of changing the switch, while with 3 whys, we can also wrap the joint with some tape. With 5 whys, we can we fix the pipe so that it does not pass through the case. It is clear how we are moving from a superficial countermeasure towards a more fundamental one that prevents recurrence.

This 5-Why thinking refers to the "*Thorough observation*" we discussed earlier. To find problems, you need to "*observe without any bias, as if you were a blank paper*" and "*find the real truths hiding behind fact*s." For this you need the attitude of "*staying there and observing for about half a day*."

If we were to word these differently, it would lead us to "*Do it all with the 5-Whys*". One thing that is important for drafting an improvement suggestion is having a way of looking at things that consider all relationships.[57] A thinking process based on a series of ideas, avoiding being entrapped by a single way of thinking.

For example, we assemble outsourced parts A and B at our workplace. Since it is troublesome to assemble parts A and B, we would like them to be assembled by the subcontractor before delivery.

In this case, if assembling them by the outsourcing contractor would reduce the assembly labor-hours, then it would be fine. If they were to increase, then everybody would probably find this outsourcing odd.

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[57] This is Job Relationship's requirement in the *'Weigh and Decide'* step to consider the action on all parties… individual, team, department, company, customer, etc. and the process of considering multiple solutions so you can choose from the best.

If you only think of improvement in your workplace, cases like this one above would often happen. When considering improvement proposals, it is important to think of one with an overall effect than includes the related departments, and not just your own workplace.

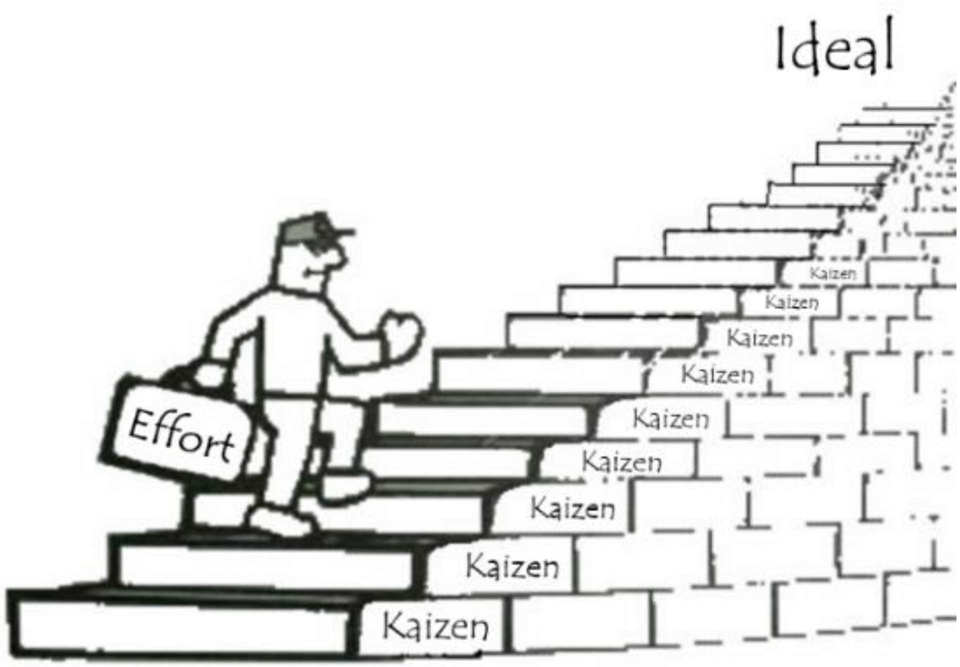
This way of thinking is especially important in a comprehensive industry such as the automobile industry. If we were to enlarge the scale even further, this would ultimately lead us to an all-Toyota improvement suggestion.

After drafting the improvement suggestion, when it comes to putting it into action, you must have the persistence that leads to its implementation. Even if you go all the way to make an improvement suggestion, it would be completely pointless if it does not get implemented. In that sense, success and failure in improvement activities are decided by the results.

Implementation is the hardest part when it comes to improvement activities. To successfully implement the improvement plan, it is necessary for others to understand, accept, and follow it.

When it comes to accepting an improvement suggestion, the more wonderful and novel it is, the more the people from the related departments will show resistance towards it.

Opportunities and actions with persistence that break through barriers proactively leading to implementation builds a house of continuous improvement. With this attitude, we repeat the improvement activities over and over, where the end of one improvement is the starting point for the next one. Improvement activities are about going up an endless stairway step-by-step. We must keep making constant efforts to improve.



Things do not go as planned

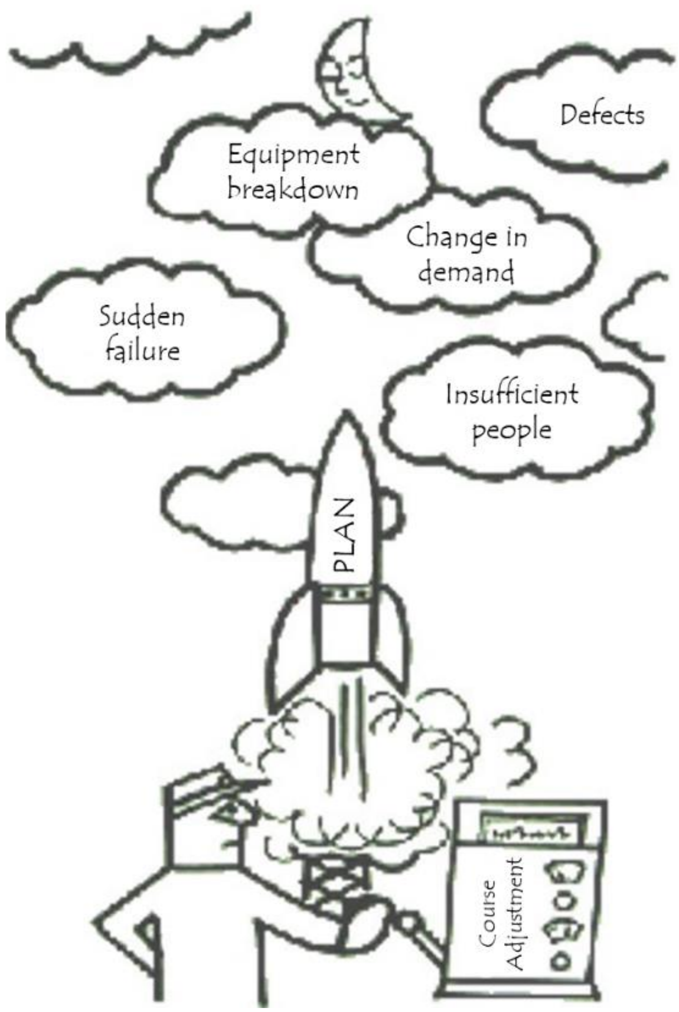
We have discussed Kanban thinking with a focus on improvement activities; now we will be discussing it from a different angle.

The fact is that things do not go the way you have decided.

To accomplish anything, we should establish the plan that is most suitable for the current actual situation. According to this plan, we set the regulations and the criteria, and give instructions and requests as we move towards its implementation.

No matter how executable the plan may seem, there are many cases when it does not go the way you have decided when you try to get it going. While there may be a difference in the extent, the things you have decided will somehow end up in a little different form.

A miscalculation that arises, no matter how strict the plan is, this miscalculation must be allowed, managed in another way, and then corrected.



This is something everyone knows if they are real practitioners. Kanban is a jewel of wisdom that the practitioner thought out to eliminate this error.

The idea that everything moves as you planned, like the idea of controlled and planned economy.

In a planned economy, where you establish your plan, implying that everything would go in the best way possible and try to make things go according to it. When it comes to the actual situation, because of actions that occur due to human nature, or the unexpected changes in the environment, everything that should have gone well (as prediction) ends in failure as the actual situation deviates from predicted.

It is not being obsessed with just moving anything as planned, it is better to take advantage of the effect of the natural adjustment on the production side to be well balanced and will work more smoothly overall.

To fill the gap between planning and execution, in addition to solving the problems on the side that is producing. As we close the gap between planning and execution, this idea is a great pillar of Kanban thinking

Section 3 - What is Kanban?

The functions of KANBAN

Kanban serves as information of work instructions (signal). This is the first function of the Kanban.

It is an automatic instruction signal where information like: "*what, when, how much, and which method would be good for production and transport*," is displayed. By looking at the Kanban, information like production amount, time, method, and sequence or transport amount, transport time, transport destination, warehouses, transportation tools, as well as containers, can all be understood.

In general, the information regarding "*What, when, and how much*" is established by those in charge of planning, in the form of written documents like: production schedules, transport schedules, production instructions, and delivery instruction forms, and then sent to the actual workplace. Doing this will certainly lead to unnecessary activity appearing all over the place.

Information like "*method of production*," "*transport destination, and warehouses*" are kept in one corner of some desk in the workplace as the work standard documents. It is difficult for people to follow the information properly and becomes one reason of producing defective work.

Consequently:

① Always being able to perform the standard operation procedure.

② Instructions that correspond to the actual condition of the workplace are automatically displayed.

③ Prevention of the flood of the extra work and papers (not documents) by those in charge of planning.

By aiming for these points, the Kanban came to existence. If the Kanban is being used, the unnecessary papers will be eliminated. The second function of Kanban is to move hand in hand with the actual goods without fail.

As mentioned earlier that "Kanban is a tool of visual management", to express this specifically, this second function together with the first function is important.

If you manage to make the actual goods and Kanban coincide without fail;

① Excessive production will be impossible.

② Production priority sequence will be known (Kanbans that keep accumulating must be rushed).

③ It is possible to manage actual goods with ease.

If the application of Kanban was done according to the two functions, the visual management that we are aiming for will become possible.

With visual management the supervisors will be able to know the following things, which are the most important for managing the workplace:

① state of compliance with the standard work

② grasping the abilities of the current production process

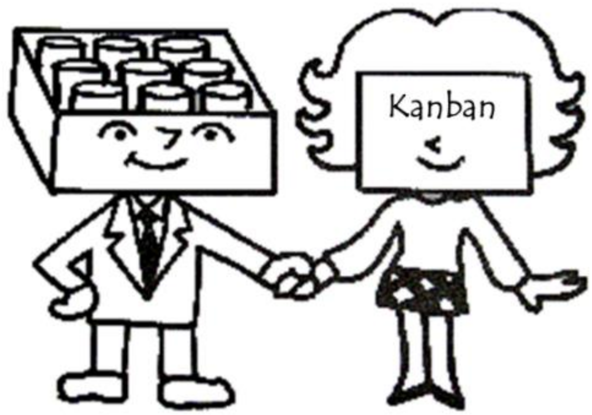
③ inventory status of the current production process

④ degree of suitability of personnel assignment in the process

⑤ progress situation of work in following process

⑥degree of urgency of the following production process (the degree of priority of the work in the current production process).

Kanban goes hand-in-hand with actual goods



To the extent of the difference, with these two functions, the people can do standard work, and the administrator can do visual management.

This too, is "KANBAN"

When we hear the word "Kanban," what comes to mind is the rectangular Kanban card in a plastic bag that is used for the delivery instruction of outsourced parts, or the metal plate Kanban that is commonly seen in an in-house production process.

Objects that are equipped with Kanban functions are also a type of Kanban.

(A) Carts can be Kanban

In our plants, when relaying assembly units like engines or transmissions in the assembly lines, we use only the designated carts; so only a certain amount can be built. Those carts perform the role of Kanban.

If there is a standard amount for inventory of units by the side of the assembly line (3-5 pieces), then the department mounting each of these units to a vehicle (for example the department that mounts the engine) will bring an empty cart, then go to the assembly line, and relay a cart that is loaded with the needed unit in exchange for the empty cart.

In this case, Kanban cards are not attached to these carts; ① by deciding the rules of relaying, and ② by controlling the number of carts, the effect will be the same as using Kanban cards.

For example, in the unit assembly lines, even if you want to produce more than the needed amount, if there are no empty carts, there would be no storage place for the completed units and the line stops (the idea of full work), and the overall assembly line too. You are unable to hold any extra inventory other than the designated inventory that is on the carts. The carts fulfill the role of the Kanban card.

In mechanical plants, there are times when the transportation of in-house produced parts between production stages is performed without the usage of Kanban cards.

Like the previous example, carts (or bins) perform the role of Kanban, and even though the Kanban cards does not exist, we can say that Kanban-regulated production and transport are being done.

(B) "*Designated seat*" is also kanban.

In our workplace, we have a lot of moving conveyors as a method for rationalizing transportation. We place the parts onto these and paint them or provide parts for assembly to the line side.

When using these conveyors to transport various parts, in order not to mistake "*when, which part, and how many we should load*," we display objects that indicate the parts needed at suitable intervals in convenient places on the conveyors; if only the indicated parts are loaded (we call these 'designated seats' that will go around with the conveyor), a smooth relay and supply of the needed parts will be possible.

Those reserved seats are a type of Kanban that functions as a kanban card. By using this sort of Kanban, we will be able to apply Kanban thinking effectively.

Wide scope of "Kanban" use

In the previous section, we understood that even if we do not have a kanban document, kanbans can exist in various forms. In this section, we continue by explaining "*Kanban can be used for managing something like this too*," by giving examples.

In drive shafts, balance weights are installed. There are five types of balance weights, and according to the degree of the unevenness of the drive shaft, we choose what is needed out of these and then install them. If there is no imbalance, we do not have to install any, and depending on the case we may need to install several balance weights. this is not an item whose amount of usage can be told from the production schedule like the other normal parts.

When dealing with parts like this, if you do not manage them well, urgent needs might arise (shortage of parts), or needless inventory might keep piling up.

This will mean that the work-in-progress schedule or the transportation schedule will have to be altered frequently, and in each production process of the balance weights production → transportation → usage, we will get in a bind as unnecessary activity and paper documents keep coming to existence as countermeasures.

For these types of production processes, until the kanban system was introduced, they went through a lot of trouble, as things did not go smoothly. Eventually they gave up saying "*since this part is like this, then it cannot be helped*."

To manage all these production processes smoothly, it is necessary to accurately grasp the number of inventory of the five types of parts present in each process, to always have the actual state of this inventory reflected, to make work-in-progress and transportation to ensure that urgent demands or excessive inventory do not happen.

To achieve such objectives, kanban was introduced to these production processes. The problematic issues that were present disappeared, and without excess paper documents, we became able to smoothly do work-in-progress, transportation and inventory management.

① by attaching kanban to the actual goods, we became able to always accurately check the actual goods,
② by having kanban go between the production processes, we became able to always do the work-in-progress and transportation in the required order,
③ as a result, we became able to keep the amount of inventory of the five types more constant, and we became able to greatly decrease the amount of inventory.

What makes this example valuable, is that sometimes there are some people who believe that "*Kanban can only be used in managing parts that are used while being stable every day*."

In the kanban rules, "*stabilization of production and levelling*" are important conditions; this does not necessarily mean that "*unless it is a part whose use is stable, kanban cannot be used*."

Kanban is not just a tool to manage common parts whose usage is stabilized, or general-purpose parts only, but it is also an effective tool for managing special parts whose usage is not stable, and that look impossible to be managed using kanban at first glance; if you correctly understand the "*Kanban thinking*," you will be able to see this clearly.

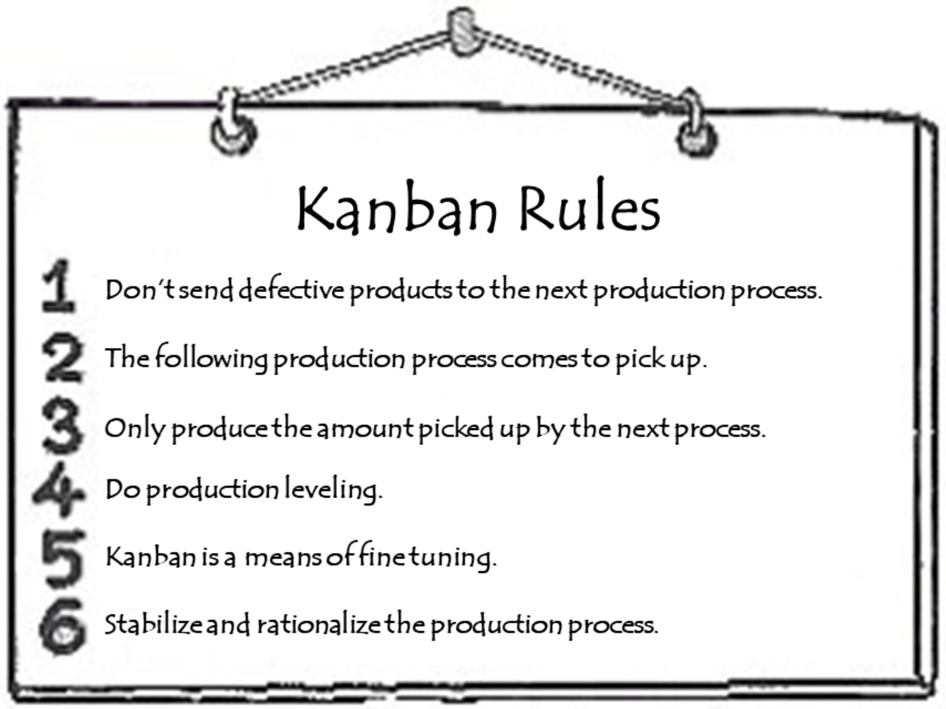
It is only after you try using kanban for the management of such parts, that you start understanding the true value of kanban. From these examples, we understand that if we use wisdom, kanban can be used for various purposes, and in many forms, and that it will demonstrate great power in leveling up the management of the workplace.

The degree of the utilization of Kanban can indicate how high the level of management of a workplace is. In this sense, kanban a jewel of wisdom of the workplace. The specific content must change and develop. If you seem to be using the same kanban forever, it would mean that this workplace is not making enough effort.

Section 4 - Kanban Rules

Every tool is effective to achieve its purpose if it is used properly, if it is mistakenly used, it will hinder achieving the target. The same thing can be said about kanban which is a tool for efficiently managing the workplace.

In this section, we describe the prerequisites for operating Kanbans, that is, the rules of Kanban.



1st Rule: No defective item sent to following process

Making defective products means consuming raw materials, equipment, and labor for the sake of something that cannot be sold. This is the worst of unnecessary activities and opposes cost reduction, which we aim for.

When the defective products are discovered we must carry out preventive measures and prioritize them over anything else, in order not to allow their manufacturing ever again. Follow this defect eliminating activity completely; 1st Rule, "*Do not send defective products to the* following *production process*".

If the 1st rule is observed:

(A) The production process that produced the defective product will be able to immediately detect the occurrence of a defective product.

(B) If left untouched, the following process stops, or defective products accumulate in its own process, so that the problem of the process is immediately realized, so that management and supervisors agree to prevent reoccurrence It is necessary to take countermeasures.

To implement this rule without fail, we must make it so that the machines, or the work automatically stops when defective products are detected. Autonomation thinking starts here.

For the Kanban system to be effective, the 1st rule must be followed. We must focus our efforts into “*autonomation*,” as it guarantees never sending defective products to the following production process.

2nd Rule: Following process comes to pick up

2nd Rule states that the following production process comes to pick up only the required amount, at the required time.

Producing items other than when required, or in quantities more than required and supplying them to the following production process will create losses in many ways.

The loss of having people doing extra work, the various types of loss caused by allowing the extra inventory, the loss of extra equipment being added even though you have surplus equipment (because you are unaware of the surplus), and the loss that arising from not being aware of equipment that becomes a “*bottleneck*”, and the greatest loss which is that in order to produce something that is not required, something that is required cannot be produced.

To eliminate such losses, the 2nd rule is extremely important. We will explain what should be done, to keep this rule without fail. If you obey the 1st rule that "*defective products should not be passed to* following *process*", defective products generated in the process can be found. There is no need for information acquired from others and you can supply items of the required quality. The timing and amount required by the following production process are not things that could be grasped from your current production process, these are known only after receiving such information from others.

It is necessary to provide this information to each production process; someone in charge of planning will appear, and something called the work-in-progress schedule will be made to contain this information will then be distributed.

The work-in-progress schedule gains its validity from establishing an assumption regarding different factors like the operation ratio of equipment or the defective product ratio; we have already explained that the actual production workplace does not move according to such assumptions.

Due to the difference between the forecast and the reality, it is impossible to respond to changes in the in-process plan finely and in a timely manner. How to successfully produce and deliver orders is a problem at any production site.

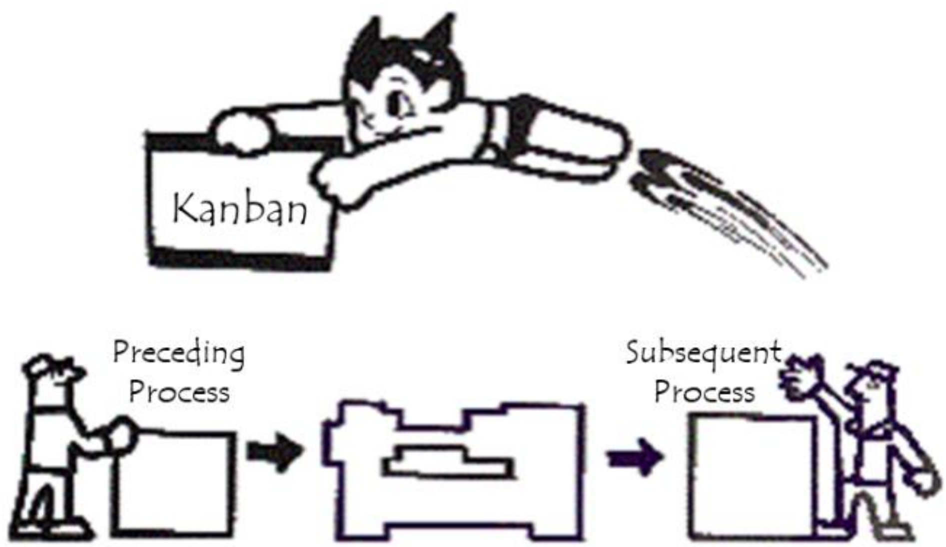
This leads to a flood of useless information, and unnecessary activities keep appearing at the workplace.

How about changing the idea of "*supplying the* following *process*," to the following process coming to take only the required amount in the required timing, or simply, the "following *process picks up*"?

From the final process which is the vehicle assembly, to the first process which is the shipping of the raw materials, all the production processes without exception, come to take only the required amount at the required time. For every process, there will be no need to acquire any information from others regarding the timing and amount that must be supplied to the following production process.

By changing the idea of "*supply*" to "*pick up*," we were able to find a way to solve a difficult problem.

The 2nd rule "*the* following *production process comes to pick up*" becomes fixed.



To prevent the following production stage from coming to take as they please, it is essential to set the rule in concrete form.

> *"Do not come to pick up without Kanban "*
> *"Do not take more than the number of Kanbans"*
> *"Kanban must be attached to the actual goods."*

The principle of using Kanbans like this is necessary for the following process to protect this 2nd rule.

3rd Rule: Only produce amount picked up

We believe that importance of the 3rd rule "*Only produce the amount picked up by the* following *process*" which appears as an extension of the 2nd rule, can be understood from the discussion in the previous section.

It is a condition to keep the inventory of the current production process to a minimum. If we follow the utilization principles like "*Picking up more than the number of Kanban is not allowed*," and "*Produce according to the order on the Kanban*," only then will the 3rd rule three be effective.

By adhering to the 2nd and 3rd rules, all the production processes in our company have the effective as if they were joined by a single conveyor and *synchronization* is established.

When we consider how introducing the conveyor line showed great power in standardizing work and reducing costs, we can fully understand the significance of *synchronization*.

4th Rule: Production Leveling [58]

To follow the 3rd rule, it is essential that all production processes have the equipment and personnel that allow them to produce only the required amount at the required time.

If we suppose that the amount and timing of picking up of the following process has variation, the preceding process will not be able to cope if it does not have surplus equipment and personnel. The earlier this process is in the flow sequence, the more essential it is to have surplus. We can never approve of such a flood of unnecessary activity.

If a preceding process does not have much surplus tries to respond to the following process, it will need to produce in advance at times when there is surplus.

We must eliminate actions that violate the 3rd rule. What shall we do to eliminate such unnecessary activity? The answer is easy, it is only necessary to eliminate variations in production.

The 4th rule is "*Do production leveling*," becomes an absolute necessity for producing as cheaply as possible. When we consider repercussions caused by the variation of the following production process are amplified in the preceding process, we find that we have an enormous duty towards production leveling of the following processes.

In the case of production processes where synchronization is thoroughly carried out with the 2nd and 3rd rules, production leveling of the final assembly process is an absolute necessity.

It is for this reason that we are currently using a computer to create a production plan that averages from all aspects as much as possible while considering various factors. In the future,

[58] This is Flow Principle #4 – Balance Demand Pace

as diversification of finished vehicles advances through expanding choices, the necessity of achieving averaging will increase. The thing to watch out here is that as diversification progresses, leveling will become more difficult.

Carrying out leveling while coping with diversification is the greatest challenge in the production workplace. It is important as a countermeasure for the facility to have dedicated equipment that adds versatility.

For example, if we have a production schedule for the Corolla, we can make a definite production schedule per month; by dividing this over the operational days, we can do leveling to the number of cars produced per day.

When we divide this into sedan and coupé, we will have no choice but to produce according to the number requested by the customers; we cannot avoid that the number of cars per day will fluctuate every ten days. The same is true for engines (1,200 cc, 1,400 cc, high speed type).

If the final assembly line was separated into lines exclusively for sedan and coupé, the leveling of production will become extremely difficult. If we make a line that can construct both sedan and coupé, leveling will become possible.

Considering that mass production by dedicated facility is the biggest weapon of cost reduction, it must be promoted thoroughly. Efforts to create a versatile dedicated production process as in the example above are even more important, while working with wisdom so as not to hinder the effectiveness of mass production (by adding minimal equipment and fixtures).

By adding this sort of thought to all the production processes, we will be able to achieve the harmony between diversification and leveling; dealing with the requests of customers in a timely manner will be possible.

Considering the expansion of the market in the future, we must promote this way of thinking more than before. It is important to understand the 4th rule, which is production leveling, while including such consideration of the facilities.

5th Rule: Kanban is a means of fine tuning

Regarding the specific content of the Kanban, as already mentioned in Section 3, one of its expressions, "*It is an automatic work instruction device intended for the people*".

When using Kanban, without particularly having to provide information like the work-in-progress schedule, or transport schedule, the Kanban alone becomes information about the production and transport instructions, and the people can do their work with only the Kanban.

Leveling of production is particularly essential. If production leveling is not being performed, what kind of problems do you think will arise?

For example, suppose that we start doing the mold setup for some press parts, it will take two days until the parts are pressed and supplied to the following production process. With this, suppose that we set up a Kanban so that instructions saying “*start the preparatory work* (mold setup)” will come out if the inventory of the press parts had become less than 2.5 days’ worth.

Suppose that the production of the following process has increased, and the inventory enough for 2.5 days was taken by the following process in 1.25; but since there are no parts made in the press production process, (2 days – 1.25 days = 0.75 day), the period of this 0.75 day, will be a state of complete stockout.

If we do things like making the inventory contain 5 days’ worth, so that we can deal with such situations, it would be unacceptable, since at times when the production amount is normal we will always have extra needless inventory.

Having the preceding process worry “*will the* following *process pick up a lot*,” and receive special information other than kanban, such as “*start the preparatory work early this time*,” will cause the workplace to fall into chaos. With this kind of consideration, we can deepen our understanding of how important "*production leveling*" is.

As can be seen from the example, kanban can only deal with fine tuning of production. Only when we start using kanban as a means of fine tuning that it starts displaying its power.

As we mentioned in section 2, “*Things do not always go the way you have decided.*”, the miscalculations that arise at that point must be managed using another method. We have explained that this is where the idea of kanban is connected.

We believe that the fact that the kanban is a means of fine tuning could be sufficiently understood.

Deciding things by “*production leveling*,” and when things do not work according to that, managing the miscalculations that arise by kanban which is useful for fine tuning, thus connecting fourth and fifth rules, and understanding them is essential.

If we assume that the fluctuation of demand cannot be avoided, then we must be ready for the fluctuation of production. If we do not think of a way so that we can deal with the fluctuation of production, together with the efforts towards production leveling, kanban will not survive.

It is important to not forget the maintenance of the kanban as it is important to continue to fine-tune the kanban while dealing with fluctuations in production.

Not only Kanban, but all the standard operating procedures in the workplace are based on a certain production amount, and if the level of the production amounts change, then revisions must correspond to the production level changes.

For the workplace, through annual planning and monthly planning, we are constantly interested in the changes in production volume, checking the number and content of kanban according to the change, producing with minimal inventory and supplying to the following process.

6th Rule: Stabilize and rationalize processes

In the 4th rule, we have learned of "*production leveling*" to achieve the purpose of making as cheap as possible while guaranteeing supply to the post-process. We need to remember the 6th rule of stabilizing and rationalizing processes.

By analyzing the 1st rule of "*not sending defective goods to the* following *process*", we understood the importance of "*autonomation*", but the meaning of this is not limited to defective parts but "*defective work*". The 6th rule will become easier to understand if it is expanded to include defective work.

Defective work means that standardization and rationalization of work has not been carried out sufficiently. This results in unnecessary activity, unevenness and unreasonableness in working hours and methods, which in turn leads to the production of defective parts.

Unless defects are eliminated, it is impossible to make as cheap as possible while guaranteeing supply to the following process. It is necessary to realize autonomation through efforts to stabilize and rationalize processes, and "*leveling production*" can demonstrate its value only after such support.

An enormous amount of effort is required keep all the 6 rules mentioned above. If we introduce Kanban without keeping such rules, Kanban will never show its effectiveness or promote cost reduction activities.

It is necessary to overcome any difficulties and to observe the rules if we recognize the effect of Kanban as a tool for management to promote cost reduction.

We have explained about the fundamental ideas as well as the details of Kanban. There is nothing whose true nature cannot be comprehended if you try implementing it as much as Kanban.

Kanban is an “jewel of wisdom” that was born from the efforts of those who are running the workplace. It is said that “*Improvement is eternal as well as infinite*.” The use of Kanbans is not limited to maintaining the current situation, but further development with creativity and effort is a task for those who are using Kanbans.

It is important to create a splendid workplace with everyone’s efforts, where wisdom and ingenuity come to life with everyone's effort.

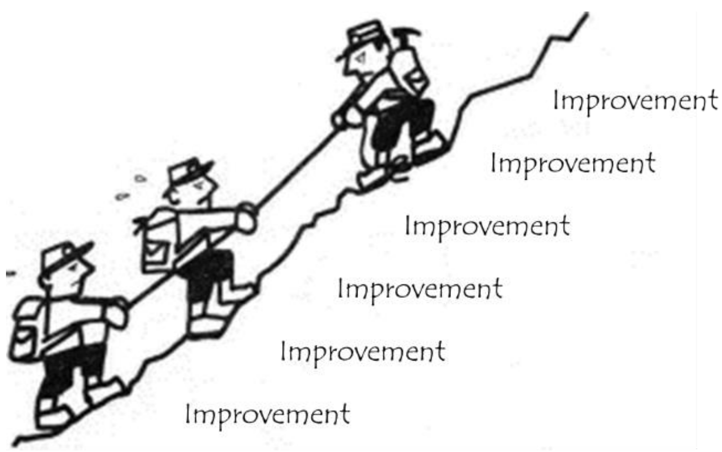
Appendix - Changing the Way of Work

Section 1 – Placement of Machines

Technological innovation is progressing rapidly. Our company's manufacturing technologies are no exception.

The placement of our machines in the machining and stamping plants, the methods of working, and their combinations are not like the present form in the beginning.

As the saying goes, "*Rome was not built in a day.*" Our company's current state was not reached overnight. Being able to maintain flow through the final production process while using very little in-process stock of parts is a result of adding one improvement to another. Like the placement of machines in a part-specific production process order, developing the idea of the Kanban system, and the combination of work.



For example, looking back at the format of the original machine factory:

(A) Each machine was arranged independently, and a person was assigned to each machine. There were cases in which two people were assigned.

(B) The person stood in front of the machine while it was "*machining*".

(C) The parts were placed on the floor, put in a box, sometimes the place was also far away from the machine and difficult to reach places.

(D) The roller conveyor was also used simply as a parts storage place where parts were piled up.

(E) The heights of the working surfaces of the machines were inconsistent; high for some machines, low for others.

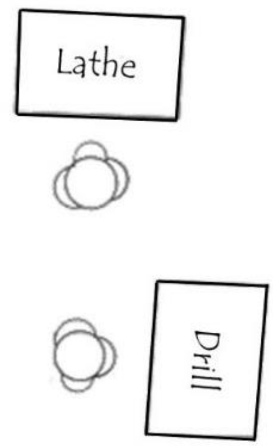
(F) The finished product was inspected by a quality inspector, delivered to the finished product warehouse, and then carried out to the assembly line.

(G) Having little in-process stock of completed goods was considered to mean that the people are slacking off, and it was believed that "*the more you have the better*".

These conditions were not limited to machining plants but were found in other plants. We will explain how we improved this, as well as the course of changing the work, while focusing on the placement of machines.

Single Placement (1 person per machine)

In the simplest way of placement; one person is assigned for each machine. The machine waits while they are mounting parts or feeding them, and while machines are working, the people are just standing still, or sometimes they are spreading oil with brushes or removing chips.

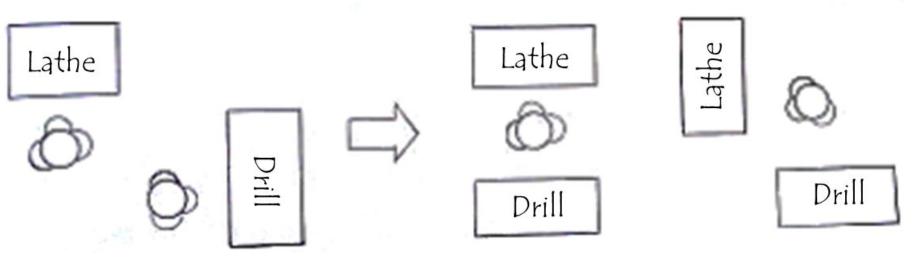


This is unnecessary activity of waiting. While the machine is working, it cannot be said that the person is working. The time spent being assigned to a machine was measured as it was included in the standard time of the part, and time spent idly watching while the machine was working was also included in the manufacturing time of the part of the process.

Type Specific Placement (2 machines per person)

With single placement, unnecessary activity of waiting is inevitably caused. To reduce the unnecessary activity, it is considered that it is possible to load and unload parts in another machine while one machine is working.

The way to do that was to place the machines in the form of the Japanese character "二" or the letter "L". It then became possible for one person to handle two machines (1946 - 1947).



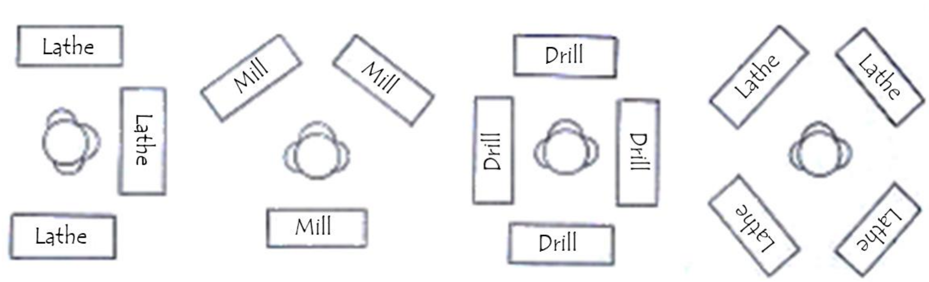
While this method is better than the one person per machine in many aspects, when you work with two machines per person, the person must pay attention on the progress of both machine's processing, making it hard to focus on one operation. Thus, it becomes hard for them to proceed confidently.

This is where we considered what was needed so that the person could feel at ease while operating two machines and thus made the following improvement:

First, we added a mechanism that stops the automatic feed once the process was complete, or we added a limit switch so that the machine would automatically stop.

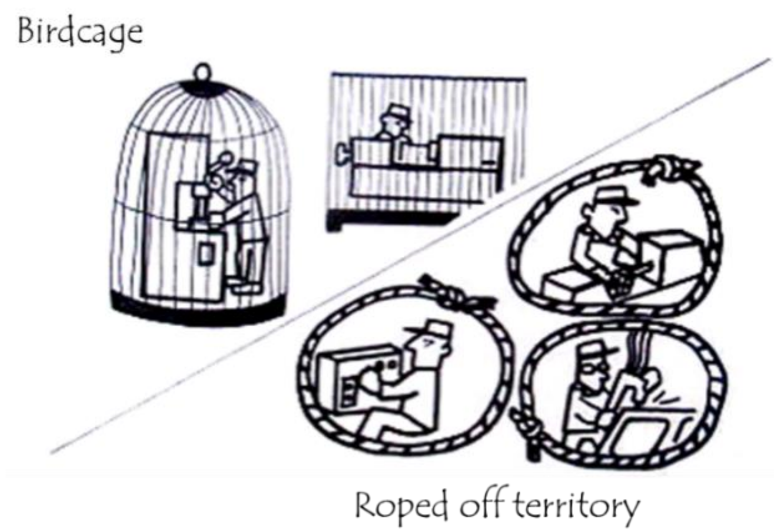
To avoid having the person look after the machine in every single step, as in chip removal, or handling the cutting lubricant, we devised mechanisms, standardized the cutting tools (shape and grinding method for tool bits and cutters), and the operator can work with peace of mind.

When we go with two machines per person, in case there is more room, we decided to place three machines in the form of the Japanese letter “コ” or in a “triangle arrangement”, or possibly four machines in a “square arrangement” and have one person handle them all.



Handling multiple machines of a similar type this way will raise the production quantity per person but leads to a tendency of overproducing semi-processed goods.

For example, the semi-processed goods which have operations by lathes or drills will pile up near their respective processes, and the parts will not flow, thus building in waiting time until they become complete products.



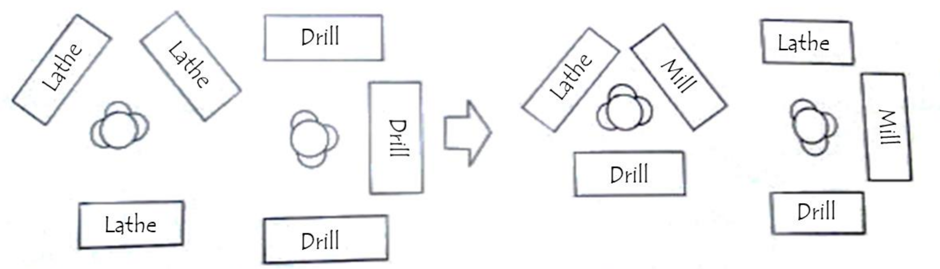
This problem was investigated, and it was improved with the placement in the production process order.

Arrangement in Process Order [59]

We have come to understand that type-specific placement eventually leads to overproduction or an increase in transportation. It has the disadvantage of having a low efficiency, making this placement format unfavorable.

When we started applying the following improvement, to suppress this overproduction of semi-processed goods. To be able to process them into finished goods in a short time right where they are, without carrying them around as much as possible.

Arranging machines in a sequence necessary for processing a part (for example: lathe, mill, drill), gradually changing the placement from type-specific placement to process order placement.



With the process order placement, the distance walked by the person is minimal. It became possible for one person to fully handle multiple machines, instead of the initial one person per machine method.

When we look at the line as a whole, it turns out that we have "*small isolated islands*" of machines, making it hard to achieve an overall balance.

The result was a pile of finished items between processes, and we were unable to achieve a staffing balance that corresponded to the fluctuation in the number of vehicles to be produced.

According to motion analysis, the best method is for the person to carry out their work in one place without walking a single step and with the least number of movements. The machines were placed with the conviction that "*walking is a bad thing*." This was the result of regarding

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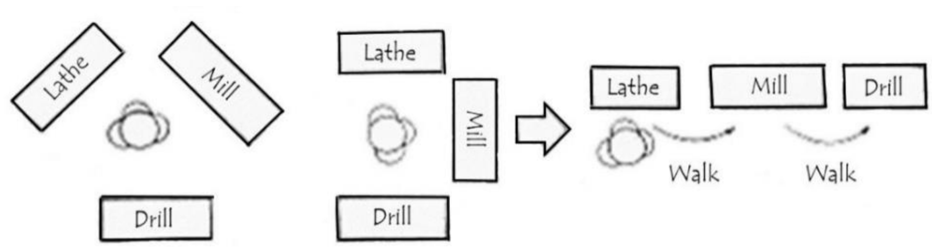
[59] This is the 1st Principle of Flow – Put Processes in Sequence.

productivity as only the efficiency of the labor of each single person, without considering the efficiency of synchronizing the whole line.[60]

Emergence of Flow Production System

To improve the flow of goods and increase productivity, we understand that walking is also a part of the person's job. We changed from surrounding the person with machines, to arranging them in a straight line. With this placement it is possible for them to handle multiple machines, even as they walk.

In the flow sequence, if we keep them as independent lines, a 0.X fraction of a person will be formed when we distribute personnel according to the number of vehicles to be produced. Since we cannot allocate a fractional person, we round the number up to 1 person, and so, we inevitably tend to over-build. When we join multiple lines together, the fractional person's work becomes incorporated into one person's worth of work.



Through work combination, we made it possible to adjust personnel placement that corresponds to the fluctuation of the required number of vehicles to be produced (corresponding to demand).

Following this process, the machine placement has reached the current state through the accumulation of research and effort of many people.

[60] This is Flow Principle #2 – Synchronize Processes.