ワーキングペーパー

Gemba Kaizen and Muda (Waste)[1]

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The Toyota production system is a method to thoroughly eliminate waste and enhance productivity. In production, "waste" refers to all elements of production that only increase cost without adding value – for example, excess people, inventory, and equipment. Too many workers, equipment, and product only increase the cost and cause secondary waste (Taiichi Ohno, (Ohno[1988]p.54).

Ⅰ　Toyota Production System (TPS) and Gemba Kaizen

1．TPS and Elimination of Muda (waste)

Taiichi Ohno, who is considered the creator of the TPS, stated: "The Toyota production system is a method to thoroughly eliminate waste" (Ohno [1988] p.54). Moreover, the Just-in-Time (JIT) approach and autonomation are the twin pillars underpinning the TPS.

"Just-in-time means that, in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed. A company establishing this flow throughout can approach zero inventory" (Ohno [1988] p.4). The conventional approach involved supplying materials from upstream to downstream processes as production progressed. However, Mr. Ohno thought outside the box and said, "Let's look at this production flow in reverse; a latter process goes to an earlier process to pick up only the right part in the quantity needed at the

1) This paper is an English translation of Chapter 3 of "Gemba Kaizen Costing- Visualization of Kaizen Effect" by Kazusa Yasuyuki and Hiiragi Shino (2023). The book consists of six chapters, of which Chapter 3 mainly discusses the Gemba Kaizen and Muda(waste). The English translation of this chapter was published as a working paper for the purpose of discussion with overseas accounting researchers.

exact time needed" (Ohno [1988] p.5). Mr. Ohno believed that the "means of indication kanban (sign board) and circulate it between each of the process [sic] to control the amount of production - that is, the amount needed" (Ohno [1988] p.5).

"The other pillar of the Toyota production system is called autonomation – not to be confused with simple automation. It is also known as automation with a human touch" (Ohno [1988] p.6).

This is based on a concept entirely different from that of conventional automatic machinery. "Many machines operate by themselves once the switch is turned on. […] With an automated machine of this type, mass production of defective products cannot be prevented. There is no built-in automatic checking system against such mishaps. This is why Toyota emphasizes autonomation – machines that can prevent such problems 'autonomously' – over simple automation" (Ohno [1988] p.6).

This concept also altered the very meaning of management. "An operator is not needed while the machine is working normally. Only when the machine stops because of an abnormal situation does it get human attention. As a result, one worker can attend several machines, making it possible to reduce the number of operators and increase production efficiency" (Ohno [1988] p.7).

Mr. Ohno expanded this concept and established "a rule that even in a manually operated production line, the workers themselves should push the stop button to halt production if any abnormality appears" (Ohno [1988] p.7). According to Mr. Ohno, Kanban is aimed at JIT and is a means to achieve it. The utility of Kanban is emphasized as follows:

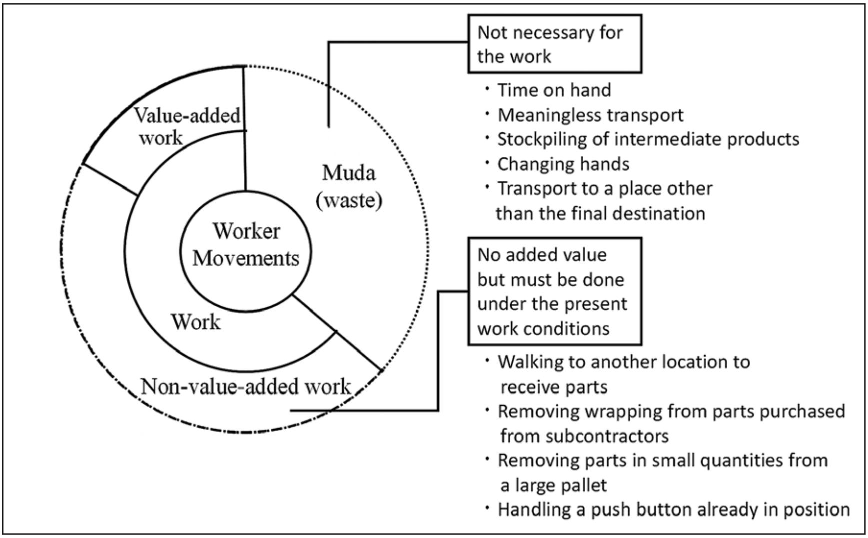
> The goal of eliminating waste is also highlighted by kanban. Its use immediately shows what is waste, allowing for creative study and improvement proposals. In the production plant, kanban is a powerful force to reduce manpower and inventory, eliminate defective products, and prevent the recurrence of breakdowns (Ohno [1988] p.29).

It is not the purpose of this book to discuss TPS in detail. For the purpose of this book, it is sufficient to confirm that the fundamental principle of TPS is to "thoroughly eliminate Muda (waste)."

2. "Movement of Workers" for Taiichi Ohno

Mr. Ohno closely examined whether the work is truly valuable for customers and defined the concept of Muda and other works at the production site: "Careful inspection of any production area reveals waste and room for improvement. [⋯] Through close observation, we can divide the movement of workers into waste and work" (Ohno [1988] p.57). **Figure 3-1** shows those divisions.

Figure 3-1 Understanding the Manufacturing Function



Source: Ohno [1988] p.58

* Based on the source, the author revised "Network" to "Value-added work" and added the Japanese term "Muda" with "waste."

As described by Mr. Ohno, "we can divide the movement of workers into waste and work" (Ohno [1988] p.57). He divided the movement of workers into: (1) waste, which is the needless, repetitious movement that must be immediately eliminated. For example, waiting for or stacking subassemblies; and (2) work, of which the two types are “non-value-added work and value-added work” (Ohno [1988] p.57).

Based on Mr. Ohno’s clear classification, this book categorizes work, which includes (1) value-added work and (2) non-value-added work, and (3) waste (or Muda) as follows:

Movement of Workers
= Muda + Non-value-added work + Value-added work
= Non-real work + Real work

In Gemba Kaizen, we typically do not immediately target “real work” for improvement. Kaizen begins by first thoroughly eliminating Muda, then reducing non-value-added work. Of course, even if these Muda and non-value-added work are eliminated, the real work itself remains unchanged. However, since the “time” workers spent on Muda and non-value-added work is reduced, the ratio of real work time to actual labor time consequently increases relatively. In other words, the “value-adding time ratio” (Fujimoto and Ikuine [2018] p.20) increases. Furthermore, as the actual working hours are reduced through Gemba Kaizen, labor productivity (output per actual working hour) increases.

In Gemba Kaizen, Muda and non-value-added work are thoroughly eliminated. “True efficiency improvement comes when we produce zero waste and bring the percentage of work to 100 percent. Since, in the Toyota production system, we must make only the amount needed, manpower must be reduced to trim excess capacity and match the needed quantity” (Ohno [1988] p.19). Mr. Ohno pointed out the following seven types of Muda:

・Waste of overproduction
・Waste of time on hand (waiting)
・Waste in transportation
・Waste of processing itself
・Waste of stock on hand (inventory)
・Waste of movement
・Waste of making defective products (Ohno [1988] pp.19-20)

This study will not explain these seven types of Muda in detail. However, particularly regarding "Waste of inventory," there is significant criticism from the perspective of responding to natural disasters like earthquakes and typhoons, as well as from the viewpoint of business models that rely on holding inventory. In response, for example, Nikkei monozukuri (The solutions magazine for design and manufacturing) writes as follows:

> Whenever Toyota Motor Corporation (hereinafter Toyota) halts production due to such disasters or other disruptions, the claim that "the weaknesses of the TPS have been exposed" invariably surfaces. Many are negative assessments of JIT, known as one of the pillars of the TPS. The typical argument is, "It's precisely because they are fixated on approaches like just-in-time—procuring only what is needed, when it is needed, and in the exact quantity required—that they end up facing situations where parts are missing." Recently, such criticisms were raised repeatedly during the so-called "first factory operation crisis," when factories worldwide were forced to adjust production due to the impact of COVID-19 (Nikkei monozukuri [2021] p.29).

The magazine continues, "But regardless of what anyone says, Toyota has never abandoned the JIT production system, nor will it ever do so. ... It is true that the JIT production system aims for the thorough elimination of 'Muda inventory.' However, the company also embraces the concept of ‘appropriate inventory.’ It maintains stockpiles of absolutely essential parts. This is part of its risk management based on business continuity planning (BCP)” (Nikkei monozukuri [2021] pp.29-30).

Furthermore, the magazine points out, “Another reason Toyota is committed to JIT production lies in human resource development. ... By keeping parts inventory to an absolute minimum, even the slightest lapse can lead to parts shortages and halt the production line. Toyota has woven into its JIT production system the belief that people develop better under such strict constraints” (Nikkei monozukuri [2021] p.31).

This means that within Toyota’s concept of Muda inventory, a certain level of inventory is permitted as part of risk management. Furthermore, it is operated based on the philosophy of developing people under strict constraints.

Mr. Ohno also made the following important point regarding the elimination of Muda:

> Eliminating these wastes completely can improve the operating efficiency by a large margin. To do this, we must make only the quantity needed, thereby releasing extra manpower. Because of this, some labor union people have been suspicious of it as a means of laying off workers. But this is not the idea. Management’s responsibility is to identify excess manpower and utilize it effectively. Hiring people when business is good and production is high just to lay them off or recruiting early retirees when recession hits are bad practices. Managers should use them with care. On the other hand, eliminating wasteful and meaningless jobs enhances the value of work for workers (Ohno [1988] p.20, Notes in parentheses are omitted).

Few executives speak such bluntly “straight talk,” but it is impressive that Toyota truly “walks the walk.” It also clearly shows how TPS is a production system that is heavily reliant on people. Our objective is to focus strongly on what Mr. Ohno called “clearly identifying surplus personnel and utilizing them effectively.” We aim to precisely grasp the Free capacity created through Gemba Kaizen and propose a new accounting theory that contributes to its effective utilization.

Ⅱ Production Process and Real Work Time

1. Movement of Workers and Muda

As mentioned earlier, the “Movement of Workers” observed on the Gemba can be categorized into three types: Muda, non-value-added work, and real work.

Of course, all three of these Movement of Workers are targets for Gemba Kaizen. That said, not all are equally prioritized for Kaizen. As Muda “should be eliminated immediately,” it is the top priority for Gemba Kaizen.

Furthermore, regarding the seven types of Muda, particularly Waste of overproduction, Mr. Ohno pointed out the following.

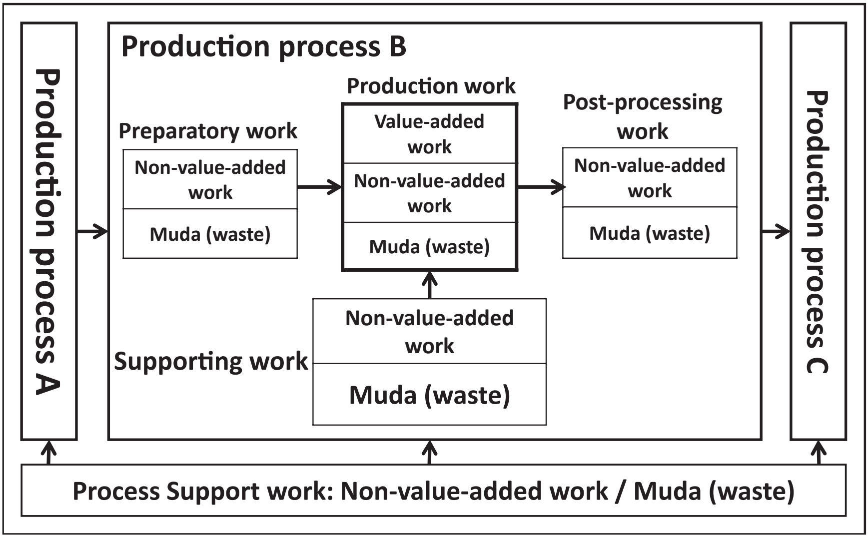
> In any manufacturing situation, we frequently see people working ahead. Instead of waiting, the worker works on the next job, so the waiting is hidden. If this situation is repeated, inventory begins to accumulate at the end of a production line or between lines. This inventory has to be moved or neatly stacked. If these movements are regarded as “work,” soon we will be unable to tell waste from work. In the Toyota production system, this phenomenon is called the waste of overproduction – our worst enemy – because it helps hide other wastes (Ohno [1988] p.59).

The fundamental Muda (our worst enemy) that Mr. Ohno identified is the “invisible Muda” hidden within the Movement of Workers. McNair ([1994] p.22) referred to it in nearly the same sense as “hidden waste.” Though normally invisible, eliminating “overproduction Muda” through Gemba Kaizen reveals hidden Muda. It is similar to spraying fluorescent paint on an invisible man. Once work and Muda are clearly distinguished, thorough

Muda elimination becomes possible.

This book presents the theory of Gemba Kaizen Costing (GKC) corresponding to Mr. Ohno's "Movement of Workers" described above. However, the classifications of real work, non-value-added work, and Muda presented by Mr. Ohno are merely conceptual frameworks for organizing the "Movement of Workers." Therefore, **Figure 3-2**, "Work and Muda in the Production Process," illustrates the application of the "Movement of Workers" concept in the production process.

Figure 3-2　Work and Muda in the Production Process



Note :

1　The production process consists of production work, preparatory work, post-processing work, and auxiliary work.

2　Production work includes Real work, Non-value-added work, and Muda.

3　Preparatory work, post-processing work, and supporting work consist of Non-value-added work and Muda.

4　The production line consists of multiple production processes and process support tasks.

5 Process support work includes Non-value-added work and Muda.
6 Through Gemba Kaizen, Non-value-added work and Muda can be eliminated from all operations.

Source: Kazusa and Hiiragi [2023] p.61

As shown in **Figure 3-2**, this production line consists of Production Process A, Production Process B, and Production Process C. Each production process involves different types of production work, but the basic structure remains the same. Each production process includes production work that involves real work, preparatory work preceding production, post-processing work performed after production, and auxiliary work for production. Additionally, process support work is established to assist the production process. While production work forms the core within the production process, preparatory work, post-processing work, and auxiliary work are also performed. However, these are not simply related, as shown in the diagram; they are often closely interrelated and complexly intertwined.

Real work that creates value is performed solely through production work; however, in most cases, it is accompanied by non-value-added work and Muda. Prior to production work, preparatory work such as preparing materials and fixtures (internal setup) and confirming machining methods and positions is performed. However, this preparatory work does not include real work. It only consists of non-value-added work and Muda. After production work, cleanup and other post-processing work are performed, but these tasks do not include any real work. They only include non-value-added work and Muda. Auxiliary work such as transport and external setup that assists production work, as well as process support work performed in factory support departments, is also non-value-added work and Muda.

In conclusion, real work that generates added value is contained solely within the production work of each production process. In contrast, non-value-added work and Muda—unfortunately—are present in all work, including production work. Thus, in the production process, there is little real work, while non-value-added work and Muda abound. It may sound ironic but the prevalence of Muda is what triggers the opportunity for Gemba Kaizen. OJT Solutions Co., Ltd. (Headquarters: Nagoya City), a consolidated subsidiary of Toyota that develops human resources through the TPS, employs numerous Kaizen professionals, called "Trainers" who have extensive experience in various Kaizen initiatives from working at Toyota. Those trainers describe this situation as "a veritable treasure trove of Muda lying dormant, just waiting for Kaizen" (OJT Solutions [2015] p.74).

Let's review the summary so far. Kaizen means eliminating the non-value-added work and Muda that overflow in the Gemba. The practical approach to Kaizen is to first completely eliminate Muda, and then to minimize non-value-added work.

2. The "Good Flow" in Design Information Transfer Theory

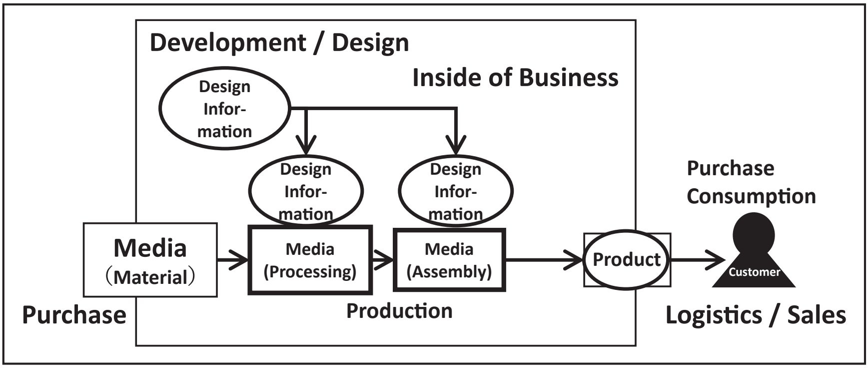
Professor Takahiro Fujimoto, a leading authority in production management research, argued that to systematically grasp the entire process of modern manufacturing enterprises, it is necessary to focus on "design information," stating as follows:

> Traditionally, in the field of production management, it was common practice to first describe production systems as material stock and flow. However, if we seek to systematically grasp the entirety of a manufacturer's production, development, marketing, competitiveness, organization, and strategy as a process, it is also important to describe the manufacturer's activities as a process for creating, communicating, and accumulating information—specifically, "product design information" that generates value for customers (Fujimoto [2001] p.26).

Professor Fujimoto proposed his unique "Design Information Transfer Theory" from the perspective of "product design information" to provide a unified description of the various activities of manufacturing companies, including development, production, purchasing, and sales (Fujimoto [2001] [2007]). Dr. Fujimoto made the argument that "The design information, in combination with its medium, progresses from the production process through the marketing process to the marketplace. Customers there purchase the product, extract and consume the design information, and enjoy whatever benefits that it confers" (Fujimoto [2007] p.4).

However, as product design information can be interpreted as including "cost information," the design information transfer theory is highly compelling even from the perspective of management accounting. **Figure 3-3** illustrates the production process, which includes machining and assembly, from the viewpoint of the Design Information Transfer Theory.

Figure 3-3 Transfer of Design Information in the Production Process



Source: Hiiragi and Kazusa [2016] p.78

According to the diagram, design information for products that meet customer needs is created in the "Development/Design" department, and this information is fed into the "Production" process, which consists of the "Processing" stage and "Assembly." The raw materials at the left end of the diagram serve as the "Media" for carrying design information. As processing progresses and design information is transferred to the raw materials, they transform from work-in-process (WIP) into finished products. Furthermore, the people and equipment processing the raw materials also act as "Media," that is, they transfer design information, just like the raw materials. The combination of this medium and the design information constitutes the product—the customer value.

The Design Information Transfer Theory states that "consumers consume products not as physical objects, but as bundles of information." Therefore, this fundamental concept can be broadly applied to manufacturing and service industries, to hard and soft goods, and to digital goods as well as analog goods (Fujimoto [2001] p.28).

The transfer of identical information to different media is called transfer, while the transformation of the same medium into information with different content is called transformation. Production activities are fundamentally a combination of transfer and transformation, that is, a combination of information transmission and reception (Fujimoto [2001] p.29) . However, in actual production processes, distances indicated by arrows inevitably exist between production processes and in "Purchase" and "Logistics/Sales" activities. Movement cannot occur without time, thus, time is consumed both between production processes and in purchase and logistics/sales activities.

In the production process, transfer and deformation errors occur during repeated transfers and the inability to accurately transfer or deform the product design information. When these errors occur, products that do not meet design specifications reach the customer. Furthermore, the diagram shown in **Figure3-3** decrease in size from left to right, signifying that the management resources invested in the production process are being wasted and depleted. Moreover, the time consumed from purchasing to delivery—that is, the production lead time—can be prolonged, potentially failing to meet customer satisfaction.

Based on this concept of Design Information Transfer Theory, Professor Fujimoto argues the following regarding Gemba Kaizen:

> The transfer of design information does not occur in a single step, but is divided into multiple processes and gradually materializes into a product.

Manufacturing involves the seamless flow of materials from upstream—where materials are fed in—to downstream to the customer, embedding design information into the product (while transferring added value at each process step). The essence of Kaizen activities is in eliminating stagnation in this flow (Fujimoto [2017] p.20).

Specifically, the ultimate ideal is a "good design" that fully satisfies customer needs and a "good flow" that means loss-free, instantaneous production. In other words, if "good design, good flow" is ultimately realized, the medium (raw materials) is instantly purchased, design information is instantly transferred and transformed, and products are instantly delivered to customers for consumption. Moreover, in this ideal state, there are no defects, and material loss and labor loss are zero. Therefore, Kaizen ultimately means eliminating Muda and non-value-added activities that hinder "good flow" to achieve this ideal state. Once these Muda and non-value-added work are eliminated, "good flow" is realized in the production process. Furthermore, in Hiiragi (2023), seven steps for achieving "good flow" through Gemba Kaizen are introduced alongside key Kaizen techniques.

3. Direct Work Time and Real Work Time

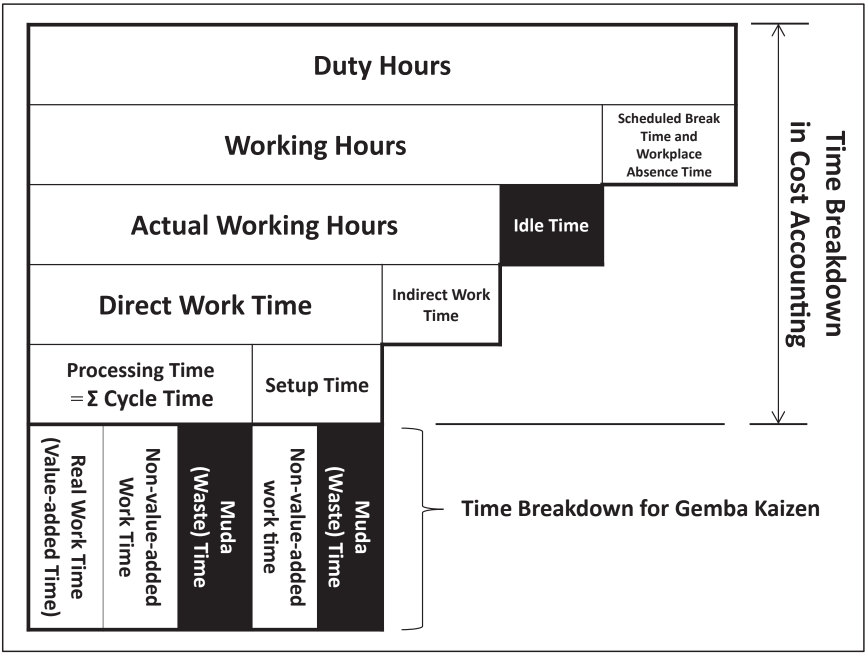
There is debate over which between reducing real work time or increasing its share should be prioritized in order to enhance labor productivity. Professor Fujimoto, from the perspective of Design Information Transfer Theory, pointed out the following:

The question is: Which approach contributes more to productivity improvement: "increasing the speed of information transfer" or "increasing the share of information transfer time"? For example, the "approach to improving transfer speed" involves accelerating the speed of assembly operations and increasing the cutting speed of machine tools. Contrarily, an approach to increase the share of transfer time involves compressing the "time not transferring design information" within the cycle time, such as "waiting time until the next cycle," "walking time," and "machine idle time." Historically, both strategies have contributed to productivity improvement. However, Japanese-style manufacturing management, exemplified by the TPS (JIT system), which focuses on eliminating "waiting" Muda, shortening mold changeover times, and reducing workpiece loading/unloading times during multi-process waiting, clearly prioritized the latter— "increasing the ratio of real work time" (reducing non-real work time). Moreover, it is a historical fact that this approach made an extremely significant contribution to enhancing the international competitiveness of Japan's assembly-based industries (such as automobiles) (Fujimoto [2001] pp.123-124).

In connection with this matter, Mr. Ohno of Toyota emphasized, "This is why I frequently emphasize that worker movement in the production area must be working, or value-adding movement. *Moving* is not necessarily working. Working means actually advancing the process toward completing the job. Worker must understand this. Manpower reduction means raising the ratio of value-added work. The ideal is to have 100 percent value-added work. This has been my greatest concern while developing the Toyota production system" (Ohno [1988] p.58). Naturally, Mr. Ohno advocates for *improving the ratio of value-added work*.

In accordance with these views, GKC requires that workers' task times be categorized according to the "movement" and "work" components of "Movement of Workers." **Figure 3-4** shows the breakdown of direct work time.

Figure 3-4　Breakdown of Direct Work Time in Gemba Kaizen Costing



Source: Kazusa and Hiiragi [2023] p.84

Figure 3-4 shows the classification of working hours, starting from the top-level "Duty Hours" to proceeding downward to "Direct work Time." As seen in **Figure 3-4**, direct work time is typically only broken down into "setup time" and "processing time" (Okamoto [2000] p.138). However, it is necessary to examine the direct work time corresponding to Mr. Ohno's "Movement of Workers" (see **Figure 3-1**). Therefore, direct work time was subdivided, and a sixth step was added.

The traditional classification of working time and the additional classification introduced by GKC can be organized from the perspective of "value-added" and "Muda" as follows. First, the third row in **Figure 3-4** shows the breakdown of working hours into actual working time and idle time (shaded). According to Professor Okamoto, "Idle time refers to downtime caused by reasons beyond the worker's control, such as being unable to work due to a power outage or waiting because of inadequate tool preparation" (Okamoto [2000] p.139) . Of course, idle time is clearly "Muda time" to anyone who sees it.

Next, the sixth row shows processing time and setup time. The setup time includes non-value-added work time and Muda time. Furthermore, processing time includes the real work time as well as non-value-added work time and Muda time. Real work time generates added value, whereas no added value is generated during both non-value-added work time and Muda time despite worker movement. This understanding is unparalleled. Therefore, it would be necessary to examine it with reference to Mr. Ohno's explanation.

> When I ask the worker how long the processing takes, he says, "This takes five minutes." When I ask how many minutes of that five minutes involve human labor, he says, "It takes 30 seconds to remove it. It takes 30 seconds to attach the next [material] and press the button. The remaining four minutes are spent by the machine doing the cutting." The actual processing time is 4 minutes, with 1 minute of human labor. Yet, they say it takes 5 minutes. So, if they finish [installation and removal] in 1 minute and then just space out for the remaining 4 minutes, they could handle the next machine for another minute, then the next for another minute—managing 5 machines would be perfectly feasible. In other countries, if you tell workers to keep working while the machines are doing the job, it's considered overwork. Japanese people do not call it overwork. Instead, they do trivial things. Since there is extra time available, I want them to do things that can be done simultaneously (Ohno [2014] p.149).

In this case, a four-minute "idle time" occurs, but the worker's perception differs from Mr. Ohno's view. At Toyota, one person handling multiple different machines or tasks is referred to as "multi-machine operation" or "multi-process operation." Through Gemba Kaizen, workers in these multi-machine or multi-process roles are trained and developed from “single-skilled workers” to “multi-skilled workers.” This approach reduces idle time and improves the ratio of real work time, delivering significant Kaizen effects. In the example, the Kaizen involves workers simultaneously handling multiple machines, yet the machine processing time remains 4 minutes. Strictly speaking, while the 4 minutes of idle time is used for material loading and unloading on other machines, thereby reducing non-value-added idle time, it does not increase real work time. Therefore, the Kaizen effect manifests as an increase in the ratio of real work time.

Furthermore, on production lines, “idle time” occurs in later processes because WIP does not flow from preceding processes. Within line production, involving multiple consecutive processes, idle time inevitably occurs at a stage unless all process cycle times are identical and synchronized. Similar idle time also occurs between operators within the same process. In Gemba Kaizen, synchronizing processes and workers are key challenges. For these reasons, working time includes real work time, non-value-added work time, and Muda time. Mr. Ohno repeatedly emphasized that non-value-added work and Muda time do not generate added value.

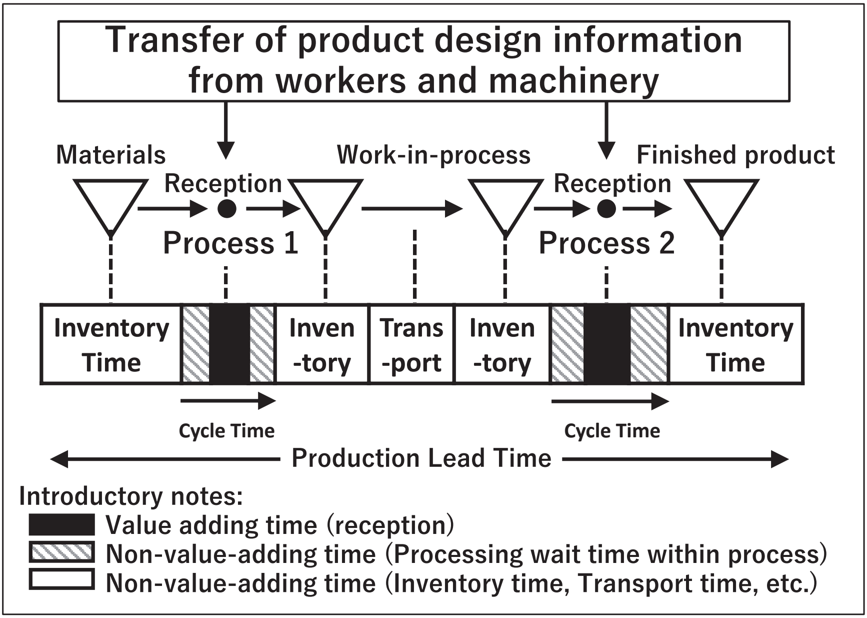
Ⅲ　Two Types of Time Concepts

1. Production Lead Time and Real Work Time

Direct work time, which serves as the foundation for cost accounting, was primarily examined as the time concept in Gemba. This section examines production lead time as another time concept emphasized in Gemba.

Professor Fujimoto’s Design Information Transfer Theory provides a highly useful perspective for understanding “real work” and “real work time” within the Movement of Workers in the context of production lead time. **Figure 3-5** illustrates a conceptual diagram of production lead time.

Figure 3-5　Production Lead Time as Information Reception (Absorption) Time (Conceptual Diagram)



Source: Fujimoto [2001] p.209

Figure 3-5 shows Process 1 as the initial stage, in which raw materials are the input and WIP is the output, and Process 2 as the final stage, in which WIP is the input and finished goods are the output. During these processes, raw materials, WIP, and finished goods are processed and stored at processes or warehouses, and transported as needed. The time taken from raw material input to finished product line-out is the production lead time, which is also sometimes called production period or throughput time.

Production lead time includes inventory time, cycle time, and transport time. Inventory time refers to the time raw materials, WIP, and finished goods remain between processes or in warehouses. Transport time is the time required to move raw materials, WIP, and finished goods. Cycle time is the time taken to pass through a process, including real work time (shaded portion) and processing wait time within the process (diagonally hatched portion).

Processes store product design information that reflect customer needs and cost data in the form of equipment, molds, Numerical Control (NC) data, operator skill levels, and work standards. The time raw materials receive product design information within the process represents the time in which added value is absorbed. Therefore, this information reception time signifies the real work time that generates added value. Waiting time within the process occurs when raw materials have not received product design information (Fujimoto [2001] pp.209-210). This processing waiting time is non-value-added time, as it does not generate added value; therefore, it is considered non-value-added time or Muda time.

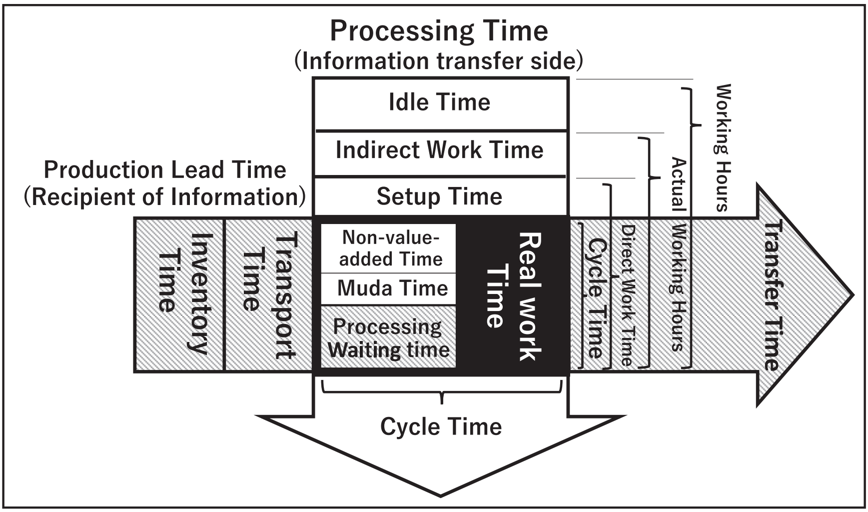
Within the production lead time, only the real work time constitutes "time in which added value is absorbed," which is extremely minimal. The remaining majority—including processing waiting time, transport time, and inventory time—constitutes "time in which added value is not absorbed" (Fujimoto [2001] pp.209-210).

According to Professor Fujimoto, "Except for production processes in the equipment manufacturing industry, where operations are fully continuous, the majority of the actual production period is actually time spent not receiving information—that is, inventory time" (Fujimoto [2001] p.210). Furthermore, based on surveys conducted in the late 1970s (Satake [1995] [1997]), it was found that even for top-tier manufacturers, the time spent receiving information (value-added absorption time) accounted for at most 1/200 to 1/300 of the entire production period, while for ordinary manufacturers it was only 1/2000 to 1/3000 (Fujimoto [2001] p.210). Additionally, Professor Fujimoto stated, "the real work time ratio on the receiving end... is estimated to be approximately 0.005% to 1%" ([2012] p.44). Based on this data, Professor Fujimoto emphasizes that "to shorten the production period, it is first and foremost necessary to compress inventory time and stagnation time, that is, 'time during which no value-added absorption occurs'" ([2001] p.210). In Gemba Kaizen, the production lead time should be shortened by excluding real work time.

2. Relationship Between the Two Types of Time Concepts

The direct work time and production lead time discussed thus far are critical time factors on the Gemba. However, but it is important to note that they are entirely different concepts. Let us consider what kind of relationship exists between the two. According to the Design Information Transfer Theory, the time of the "transfer side" and the time of the "receiving side" are identical to the cycle time of the process during which the transfer occurs. Furthermore, the time during which the process (worker/machine equipment) occupies the medium (raw materials/WIP) is defined as the "medium occupancy time" (Fujimoto [2012] pp.43-44) . Therefore, the media occupancy time becomes the cycle time. This means that within the process, the two types of time—the time in which the transfer side (e.g., workers or machinery) transfers design information, and the time in which the receiver side (e.g., raw materials or WIP) receives information) —share the same time. **Figure 3-6** organizes the flow of these two times and their intersection in a conceptual diagram.

Figure 3-6 The Relationship and Intersection of Two Types of Time Concepts



Source: Kazusa and Hiiragi [2023] p.87

In **Figure 3-6**, the vertical arrows represent the time of the processing side. As this assumes manual work by one worker, it indicates the time involved for the single direct worker performing the task.

Direct workers report to the factory and perform duties at their assigned processes. This time constitutes Duty Hours. As shown in **Figure 3-4**, Working Hours are derived by subtracting Scheduled Break Time and Workplace Absence Time from Duty Hours. Subtracting Idle Time from Working Hours yields Actual Working Hours. Furthermore, Actual Working Hours are categorized into Indirect Work Time and Direct Work Time. Processing Time, which is the cycle time during which the worker processes the item during the process, is derived from Direct Work Time by subtracting Setup Time.

In **Figure 3-6**, the vertical arrow represents the sequence for direct workers on the process: Idle Time when work cannot proceed due to a lack of material (WIP) flowing from the preceding process; Indirect Work Time spent performing non-direct work; Setup Time spent preparing for material processing; the cycle time for processing the material that has flowed in from the preceding process.

Contrarily, the horizontal arrow represents the material's lead time. Material processed in the preceding process is temporarily held as inter-process inventory (Inventory Time) before being transported to the current process for processing (Processing Time) . The time required for this material to be processed corresponds to the Cycle Time. It is then transported to the next process (Transport Time), following this sequence.

Two important points are notable here. First, only the cycle time corresponds to the time in which the two arrows in **Figure 3-6** intersect vertically and horizontally. At that point alone, the direct work time and product lead time coincide.

Second, cycle time is further subdivided. For workers, the time during which the item is present within their assigned process and the time actually spent processing it constitute the real work time. Other times, such as retrieving tools from shelves or adjusting machinery, are essentially non-value-added work.

Within the cycle time, idle time for the worker becomes waiting time for the WIP. In **Figure 3-6**, the "non-value-added work time" and "Muda time" included in the direct work time, and the "waiting time" included in the production lead time, represent the same time under different names. For the worker, these are "non-value-added time" and "Muda time," that is, "non-real work time." However, the same time is "Processing Waiting Time" for the WIP being processed. Minimizing non-real work time and "increasing the ratio of real work time" was the essence of TPS envisioned by Mr. Ohno ([1988] p.58).

Traditional cost accounting has primarily focused on direct work time, as indicated by the vertical arrow. However, to comprehensively grasp the Gemba Kaizen effect, a new cost accounting approach must be explored. This approach must fully consider both time concepts—including the lead time represented by the horizontal arrow—and how time overlaps at their intersection points.

In the field of production management, the importance of lead time has long been recognized. However, few attempts have been made to integrate it into the fundamental structure of cost accounting while contrasting it with processing time. If GKC aims to achieve this, it is necessary to organize the various time elements managed in actual manufacturing operations. This chapter fills this gap.

As detailed in this chapter, direct work time includes real work time, non-value-added work, and Muda time. Typically, in cost accounting, direct labor costs are calculated by multiplying the labor rate by the direct work time. The direct work time used here includes non-value-added work time and Muda time, which do not generate added value. Therefore, in GKC, direct labor costs are calculated by excluding non-value-added work time and Muda time from direct work time—this is called real cost. Other costs are calculated as non-value-added costs or Muda costs.

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