東邦学誌第51巻第２号
2022年12月
論　文

International Comparison about Management Organizations for Lean Production —A Trial Comparison Study between Sweden and Japan—

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Abstract

The purpose of this paper is to compare Sweden and Japan from the perspective of engineers' activities and examines their distinctive ways of behaving. This research angle about the behavior of engineers on the manufacturing process is an important point of discussion in terms of an international comparison of production systems. Because how the means and methods of production is managed and how these management actions are set up by organization are to reveal essential contents and the basic characteristics of the production concept. Therefore, this paper focuses on the process of setting up standard work, divides engineers into two categories, production engineers and manufacturing engineers, and adds team leaders to compare their functions in setting up standard work in Swedish and Japanese factories. The study shows that Swedish teams have expanded the role of team standard work and have a wider range of team roles compared to Japanese factories. Although the production engineers are involved in setting up the standard work, they have more influence in setting up the standard work in Japan than in Sweden, where they provide support in a supporting role.

1　Introduction

Since the 1990s, the Lean Production System, LPS, and the Toyota Production System, TPS, modeled on Japanese companies have been extensively introduced to overseas companies in various forms and have enhanced the influence. In Sweden which this paper is going to focus on, the production management approaches modeled on Japanese companies have been introduced increasingly.[1] As a result, various Japanese production management approaches including 5S, and Kaizen, Andon, JIT, Kanban have been introduced. On the other hand, some changes have been brought to the mechanical engineering system that promotes production and introduction of production lines using belt conveyors have been advanced.

Based on the hearing at a CBU (Completely Built-Up or Completely Assembling) automobile factory in Sweden, this paper makes a comparative review of the following topics while focusing on the "standard operation" and "division of

1 Lean production was named in The Machine that Changed World [1990] by Womacks. The production concept modeled on Japanese automobile companies.

labor." The topics are: the kind of changes brought about by the introduction of Japanese production systems, the reasons why the Japanese production systems as typified by TPS are going to be accepted in Sweden, and the characteristics of the Japanese production systems as seen in the case example of introduction in Sweden.

After the 2010s, before and after Corona disease (COVID19) spreading, production systems have been changed rapidly and turned into DX: digital transformation called as the Industry 4.0. In Sweden the DX and Industry 4.0 which have been developed are called "Smart Factory". In the process of this transforming, there is a need to discuss the current situation of the division of labor for making new production models. This paper offers key points for discussion to build combined and integrated organization from division of labor based on the practice of Japanese factories.

2 Viewpoints for Discussion on this Research and Background of Theme Setting

2-1 Viewpoint for Discussion- Standard Operation and Division of Labor

When a Japanese production system such as LPS or TPS is introduced, frictions are often caused between the two existing domains, i.e., the technical conditions and the social conditions. Behind it, it would appear that technical management in Japanese companies has unique features which are not seen in Western countries. The theme of this paper is to focus on the "standard operation" and "division of labor" and to present uniqueness and problems in technology and labor management method in Japanese companies.

The reason to set the standard operation at the analysis viewpoint is that the standard operation is the base for task control in contemporary industries. Also, the standard operation contains the process from setting, implementation, and correction, which result in improvement, and various task types in production workplace are involved in each step of the standard operation. Therefore, analysis of the standard operation allows us to grasp the production management conditions. Furthermore, setting the standard operation and its management as the analysis criteria has another advantage of evaluating world factories and companies with a given criteria. Like the standard operation, improvement that means modification of the standard contents could be compared following the process. (See Tamura [2011].)

Next, let's focus on the "division of labor." In a series of the processes of setting of the standard operation, its execution and its modification, points to consider are as follows; who sets the standard operation and in what way, and who executes it and who modifies it and in what way. The conventional discussions made both at home and abroad have conveyed the image that operators make use of a team (a work group) and execute and manage operations based on their experience (KOIKE, Kazuo [2008]). In many cases, however, factory engineers, as well as operators, are actually involved in management of the standard operation. Therefore, a concern is aroused over the relation between the standard operation and division of labor (NAKAOKA, Tetsuro; ASAO, Uichi; TAMURA, Yutaka; FUJITA, Eishi [2005]). Manpower, positions, and divisions involved in the standard operation vary in different companies. Comparison of management of the standard operation from the aspect of division of labor would allow us to examine the management characteristics of companies in

different countries.

2-2 Background of Theme Setting – Characteristics of Japanese Production and Structure of Division of Labor

This paper compares Japanese companies and Swedish ones in terms of the relation between the standard operation and division of labor. First, let me indicate the characteristics of management of the standard operation and division of managerial work in Japan.

Three distinctive Japanese elements are found in the characteristics of management of the standard operations. The first one is that management is hierarchically divided on the side of engineers. Japanese companies develop two types of engineers, that is, production engineers, who consider the concept and layout of production facilities required in the production process, and manufacturing engineers, who consider improvement of workability from technical viewpoints. In particular, manufacturing engineers are involved in the basic design of the standard operation and assume the role of understanding production work from the technical aspect though they are engineers. They stand between engineers and operators. In Western nations, the position of manufacturing engineers has not been established. Manufacturing engineering greatly represents the characteristics of Japanese management.

Another one is organizationally-built cooperative relations between production- manufacturing engineers and shop-floor workers. Taking the standard operation as an example, its draft is prepared by manufacturing engineers by the start of the production preparatory stage, and it is finalized after inputting comments of shop-floor workers. After the launch of mass-production, the standard operation is managed by shop-floor workers. If the standard operation is improved, changed, or corrected, it is checked by manufacturing engineers. The task of manufacturing engineers is to listen to workers' complaints about working conditions routinely and identify problems. Manufacturing engineers and workers have a definite division of roles while maintaining cooperative relations.

Thus, as the last characteristics, we can point out that production is managed through three-level division of labor: by a production engineer, a manufacturing engineer, and team leader who is one of a member of a team in the overall operation management in Japanese companies. Above all, setting a unique position of a manufacturing engineer enables the creation of an organizational system which encourages operators to cooperate with the engineer side. With this system, operation information is fed back to the engineer side. The structure of three-level division of labor is an organizational foundation that guarantees sustainment of production management in Japanese companies (Tamura [2011]) .

In Western companies, the cooperative relation between engineers and operators does not function sufficiently, and in many cases, a gap in operation information develops between engineers and operators. Therefore, engineers cannot grasp operation information and operation conditions sufficiently. This is also reflection of a warp in the division style.

2-3 Buildup of Production Information and Production Organization to Materialize Product Design Information

As Fujimoto [2003] points out about the relation between the production process and product design, the product process is the process of "transcription" of product information shown on a design drawing to a product. However, in order to examine the know-how of the production process, it is necessary to analyze the transcription process independently. This is because a product drawing contains the description of sizes and quality specification, but the information for actually manufacturing the product is not accompanied.

The information for an actual behavior of production is herein collectively called "Production Information." It is described in the "Process Capability Chart" or "Manufacturing Process Chart." For operations, the "Standard Operation Chart" or "Work Instructions" are prepared to instruct operations. For transcription of product design information to physical products, it is necessary to transform the product design information into production information in order to do production and to construct a production organization that uses production information to actually produce products conforming to QCD.

2-4 Subject of Investigation – Structure of Division of Labor and Existence of Management Know-How

The advantage of the Japanese three-level production management system appears most distinctively in the process where production engineers' knowledge on facility design, manufacturing engineers' expertise on working process, and operators' experience are integrated. For example, product information and production information are approximated each other in the product design stage and almost completed product drawings are provided in a stage before the start of mass-production. For preparation of such matured product drawings, information collection from all three levels is indispensable.

After the start of mass-production, by the manufacturing engineering continues functionally, which allows engineers to step into the labor process. Consequently, at the time of product change-over, the input of new production facilities, production rationalization, and a new suggestion on works, operation information can be evaluated from the engineers' viewpoint and the response to any changes is quick and easy. Needless to say, for routine workability improvement around the job site aiming at working loss reduction, cooperation between team leaders and manufacturing engineers is absolutely necessary.

In actuality, the types and contents of production information needed for production management and operation management depend on companies. Moreover, collection and use of production information tend to be greatly influenced by the organizational situation and structure of factories and companies. The method for collecting and utilizing production information exists as the organizational know-how of production management for individual companies, however, hardly recognize to the surface. With the three-level type management as the de facto premise of the organization, the production management of Japanese companies holds such organizational know-how.[2]

Table 1 Survey Slip

	Planning	Testing	Execution	Analyzing
OP				
TL				
ATL				

Introduction of the Japanese production approaches, including TPS and LPS, means change of the structure of division of labor and the operation principal in a production organization. In Japanese companies, it is supposed that integration of production capacity with engineers and operators has enabled such approaches. Based on the above-mentioned theoretical hypothesis, this paper clarifies the structure of division of labor in Swedish factories and evaluate the position of manufacturing engineering roles in the production management function, thereby using them as the evaluation axis for the introduction of LPS and TPS.

3. Analysis Method

In order to clarify the relation between the standard operation and the division of labor, this paper adopts the hearing approach based on the survey slip as shown in **Table 1.**[3] The vertical axis of the Table shows the role levels used at a workplace. These role levels are commonly used at production workplaces where mass-production is oriented. When viewed in relation to management of the standard operation, information on production and labor is collected making use of these role levels and is converted into textual information to prepare the administrative record file for the standard operation. In contrast, the horizontal axis shows the management items. Namely, this is the necessary process for preparation, execution, and improvement (= modification) of the standard operation. With this table, you would be able to understand a kind of job position is involved in a certain specific duty.[4]

4 Survey Results – Comparison of Standard Operation Management

Tables 2 to **5** show the survey results. As for the characteristics of sample factories where hearing was conducted, Factories A and B are under the strong influence of Swedish Team System. On the other hand, Factories C and J are strongly affected by Lean Production System.[5]

2 The reason we call it "organizational know-how" is that the various pieces of information needed to advance production are formed organizationally, via organizational pathways within the firm. The formation, modification of production information among engineers or in between engineer and team leader, that is not understood as an individual human role. In this paper, the analysis is; the functions and roles of production and manufacturing as an organizational function, and the point of consideration is; how production information is formed and modified. Even though the role of manufacturing engineering is generally carried by "production engineers," whether the role and function of manufacturing engineering is established as a job role is also an issue for consideration here.

3 Hearing was given to Swedish engineers, such as process engineers, in charge of manufacturing processes. The hearing sheet in Table 1 was used. Hearings were conducted at two commercial vehicle manufacturers, a passenger vehicle manufacturer, a machinery manufacturer, and a Japanese-affiliated transport machinery manufacturer in September 2010 and March 2011. Thereafter, research done at Japanese affiliated factories in Asian areas was added (Tamura [2017]).

4 For the abbreviation such as TL, ME and PE used in the text, see the description under Table 5.

5 In order to distinguish Japanese-affiliated factories located in Sweden, factories located in Japan are hereinafter called “Japanese factories.”

4-1 Management of Standard Operation and Division of Labor

4-1-1 Conditions of Standard Management in Swedish Companies

Let's think about management conditions of the standard operation. The point of focus is which job level is in charge of an item of management of the standard operation on the vertical axis.

Table 2 Swedish Factory A Producing Passenger Vehicles

	Planning	Testing	Execution	Analyzing	Evaluation	Feed Back	Education
Operator		○	◎		○		○
TL	◎	◎	○	◎	◎▽	◎	◎
ATL							
SV				◎		◎	◎
TPS Team							
Manu.Engineer							
Process.Engineer	○	○		○			
Product.Engineer							
Manager							

Note) Linear flow operation at a mass production type factory.

Table 3 Swedish Factory B Production Commercial Vehicles

	Planning	Testing	Execution	Analyzing	Evaluation	Feed Back	Education
Operator	○	○	◎	○	○	○	○
TL	◎	◎	◎	◎	◎	◎	
ATL							
SV							
TPS Team							
Manufact.Eng							
Product. Eng							
Process. Eng.	○	○	–	○	○	○	○
Manage							

Note) The belt conveyor is not used, but flow operation is adopted.

Table 4 Swedish Factory C for assembling machinery

	Planning	Testing	Execution	Analyzing	Evaluation	Feed Back	Education
Operator	○	○	◎	○			○
TL	–	–	–	–	–	–	–
ATL	–	–	–	–	–	–	–
SV	▽	▽	▽	▽	▽	▽	▽
TPS Team	◎			◎	◎	◎	○
Manufact.Eng	◎	◎	○	◎	◎	◎	◎
Product. Eng							
Process. Eng.							
Manage	○						

Note) A small scale factory with 40 operators in the assembly division

Table 5 Japanese-affiliated Factory J for transport machinery

	Planning	Testing	Execution	Analyzing	Evaluation	Feed Back	Education
Operator	○	○	◎	○			
TL	◎	◎	◎	◎	◎	○	,◎
ATL	◎	▽	◎	◎	◎	◎	◎
SV			▽	▽	▽	▽	▽
TPS Team							
Manufact.Eng							
Product. Eng							
Process. Eng.	○			○	○	◎	
Manage							

Note) A linear flow is introduced into the production line. A Japanese company acquired the ownership 6 years ago.

Symbols used: ○: participant ◎: main participant ▽: decision maker

Leftmost columns from the top to the bottom: Operator, Team Leader (TL), Assistant Team Leader (ATL), Supervisor (SV),

TPS Team, Manufacturing Engineer (ME), Process Engineer, Product Engineer, Manager

At Factories A and B which follow the Swedish management style, operators such as teams and team leaders (TL) are involved largely in the processes from design to execution of the standard operation. It is suggested by the fact that the marks of ○ and ◎ are intensively distributed to TL at Factories A and B (Tables 2 and 3). In particular, TL assumes the role of Evaluation and Feed Back at Factories A and B. Thus, we could infer that, at Swedish factories, considerable discretion is given to the TL job class when establishing and executing the standard operation. Especially at Factory B, Teams are involved in preparation, execution, and evaluation of the standard operation. Thus, we could infer that TL and Team are more likely to have room for judgment in management of the standard operation.

In contrast, at Factory C and Japanese-affiliated Factory J, ◎ and ▽ distribute to the engineer side beyond TL. This suggest that administrative competence to decide the content of the standard operation is controlled by a class having a

higher level of organizational power (Tables 4 and 5). It can be implied that establishment and execution of the standard operation at the Japanese-affiliated Factory J are maintained through cooperation of <Team and Engineer>. Accordingly, the Team's range of power and administrative competence to enable to design the operation by themselves is narrower than that at Factories A and B.

As seen above, at the factory influenced by Swedish concept of Team, the Team side is greatly counted on in terms of the management of the standard operation. On the other hand, at the companies affected by LPS, there is a possibility that involvement of engineers is increasing.

4-1-2 Role of Engineer

At Factory A where LPS is not introduced, process engineers are in charge of Production Planning, Testing, and Production Analyzing. Similarly, in an interview at Factory B, process engineers reply that they are in charge of a range from Product Planning to most items of the standard operation. Compared with Factory A, the extensive role of process engineers at Factory B draw our attention. According to an interview at Factory B, the Team side assumes most of the necessary matters of the standard operation and the engineer side supports the Team.

Next, let's consider Factories C and J where LPS is introduced. The role of engineers at Factory C is to cover most of the management items regarding the standard operation as "◎ = Main Participant." It deserves attention that the role of engineers at Factory C covers a wide range of facility and labor though the final decision of the management items is given by SV. Since TPS team is formed to fulfil the Team's role, the Main Participant specializes in executing operation.

How then is the Japanese-affiliated Factory J? Before the introduction of LPS into Factory J, operations were managed with the Team placed in the nearly stationary condition and the function of the Team covered Planning, Analyzing, and Evaluation. Therefore, the role of engineers is limited to such items as Analyzing, Evaluation and Feed Back. Among them, the role of Feed Back that takes in the operation condition into the engineer side is important.

4-1-3 Difference in Support for Team

Next, let's investigate the relation between the Engineer and the Team. According to the interview at Factory A, the respondents indicated that the main role of process engineers is to untangle problems the Team is facing and give advice to solve the problems. The respondents at Factory B also emphasize that process engineers put importance on support for the Team, though it is not directly shown in the Table.

According to the interview at Factory B, the "support" activity is not based on the socially vertical relation between the engineers and the team but on the equality of both parties. We had the impression that the relation between the engineers and the team is not confrontational and a hierarchy of rank in the office organization is not a major part of their relation.

The team does not accept the instructions of the engineer side one-sidedly. A possible reason for it is that engineers are supplied from the operator side, too. Thus, both parties are likely to have built a good relation and are able to sustain it. In contrast, engineers of Factory C and Japanese-affiliated Factory J also extend support to the field team like Factories A and B. As seen in the items of each table, however, the role of these engineers are tends to focus strongly on the administrative functions, such as planning and evaluation. It is assumed that there is an administrative structure in which the approval is given from TL to engineers regarding the contents of the standard operation and the preparation and checking of the standard operation chart.

4-1-4 Engineers' Career

What career is required when a worker is promoted to an engineer's position in Sweden? Except for Japanese-affiliated Factory J, four process engineers in Swedish companies worked as operator for four years or several more years after joining the company, then proceeded to the position of engineer on their own will. The hearings at Factories A and B have revealed that the process engineer was their first position as engineer. The positions of engineers are various including production, manufacturing, products and processes. They remain at each position for up to 4 years before transfer.[6]

The scope of tasks of a process engineer consists of groups based on a series of tasks and roles in the process where objects of control are placed on the line. In most cases, the assembly process is finely divided depending on production particulars and the scope of tasks of process engineers consists of groups of an object of management based on a series of jobs on the line. About three teams are in place in a process. Therefore, their domain of management is narrower than the one in Japan.

A certain number of manufacturing engineers in Japanese factories are occupied by workers coming from production sites.[7] In Swedish factories, engineers are more likely to build their career through internal promotion at the factory. In Sweden, too, we suppose that the position of factory engineers tends to be developed in the internal promotion style.

4-1-5 Role of SV-level workers

Now, let's consider the role of SV-level workers who are positioned at the top of the managerial layer. In many cases, SV-level workers are immediately employed after graduation from universities. They are usually directly supplied from the external labor market. The task of SV is mainly preparation of reports on production management and business conditions for the management side, and SV are seldom involved in the actual production activities. The long-term stability of the position of SV is not enough. It suggest that the role of SV entails a number of possible problems because

6 In case of Factory B, for example, engineers transfer from Process through Product to SV. Actually, senior job positions are provided and one job position is subdivided.

7 Koike [2008] Chapter 4 mentions that the main group of manufacturing engineers was person who had worked as manufacturing engineer since entering the company, and they have the school career of manufacturing engineers; that is, 30% are senior high school graduates, 30% are graduates from college of technology, 30% are university graduates and 10% are graduates from graduate schools. The ratio of experienced manufacturing operators is unknown (Koike [2008] p.102).

internal experiences, which are an advantage of the internal promotion, cannot be obtained. Supposedly the internal promotion type career is disconnected between SV and process engineers.

5. Consideration and Evaluation

5-1 Labor Regulation in Sweden

We have learned through this comparison that Team at Factories A and B, especially at Factory B, sustains a very significant capability in designing, implementing and amending processes of the standard operation. At Factory A, which is less than Factory B, TL on the team side is involved in design, analysis, evaluation, and training for the standard operation. Thus, we can see that the Team side is extensively involved in the standard operation.

Based on the investigations conducted in Japanese factories to the present, there is little room for independent decisions by the operator side when designing and implementing the operation standard. Even in the occurrence of a "trouble" during working, the procedures to respond to an abnormality or a problems have been prepared (Nakaoka, Asao, Tamura and Fujita [2005]) and there is little room for operators to make independent decisions. Accordingly, we can evaluate that the power Swedish teams have for formation and operation is relatively larger than the power Japanese teams have.

5-2 Engineers and Team at Swedish Factories

At Factories A and B that follow the Swedish trend, the team has high job design capability.[8] Therefore, they keep the horizontal relation with engineers. Engineers are in charge of facility design as production engineer and extend support to the work area. On the other hand, at Factories C and J, where the Lean Production System is introduced, operation management is extended to the engineer layer thereby strengthening the vertical relation. The relation between the team and the engineers seems to be increasingly vertical.

5-3 Position of Swedish Type

5-3-1 Will LPS Produce a New Type of Engineer?

At the companies where LPS is introduced, the management power for operation design sustained by Swedish conventional teams is being shifted to the engineer side. Consequently, two changes would be brought about. The first change is the contraction of the Swedish team's operation design function. On the other hand, the role of engineers would change qualitatively. In the past, the role of Western engineers covered facilities and operations, including production facilities, mechanical facilities, quantified production management, and operation design. In Sweden, engineers handling operation information are likely to have emerged.

In Japan, ME's (Manufacturing Engineer) have already assumed the position of an engineer who has access to operation

8 As a problem on the Swedish side, it could be pointed out that the engineer side cannot grasp the detailed operation information precisely (according to the interview at Engineering Division, Headquarter of Factory A).

in formation or shares the technical area with operators. In Western companies, this position has not been established yet. Formation of the position of ME is an important index that can be positioned as a "merkmal" for formation of Japanese-style management. In Sweden, this position could be being formed through the introduction of LPS.

5-3-2 International Comparison

Fig. 1 shows the structure of division of labor. It shows three categories of "Production Engineer" that cooperates and coordinates the design division and manages the production facilities as an organizational function, "Manufacturing Engineer" that manages the operation process from the aspect of labor, especially in relation to man-machine interactivities, and "Team" that is in charge of operation. It also presents the relation of division of labor among three parties in each country (Tamura [2011]).

First, Type W is the traditional division of labor in the West, mainly in the U.S. It features no placement of manufacturing engineers and clear separation between concept or planning and execution or doing in the production process (indicated by x). Accordingly, it is difficult to adjust the product design information and the standard operation information which means operation fulfillment information. Furthermore, problems or points of improvement occurring in the course of product fulfillment are not fed back to the concept of the design process and production process.

Next, Type J is the Japanese type. In this type, manufacturing engineers act as a bridge between production engineering and team activities, and thereby connect the concept and the implementation process for production. The standard operation is managed by manufacturing engineers and teams in a decentralized manner. It is possible to solve a problems during production fulfillment through cooperation with teams under the control of manufacturing engineers.

The last Type S is the Swedish type. It features management of the standard operation by teams and support extended to teams by manufacturing engineers. Teams play a major role in managing the standard operation and fulfilling the standard operation. Swedish team's function and Swedish team's management area are relatively wide, they do Planning/

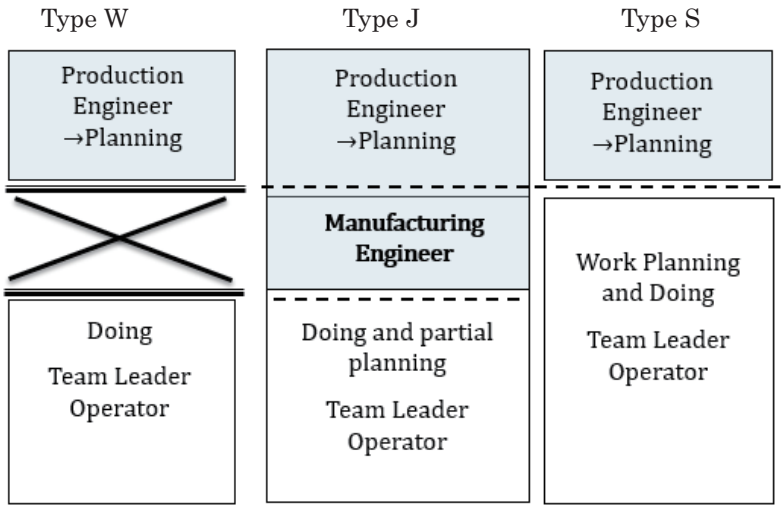

Fig. 1 International Comparison of Structure of Division of Labor

Doing with engineers. It seems that the relationship between engineer and team, which is regulated on interorganizational relationship centered on the team can be observed.

5-3-3 Development of Swedish Type – Bipolarization?

At many Swedish factories, Type S factories affected by LPS imitates Type J and tries to shift to Type J. Alternatively, it is estimated that their shift to Type J is not successful and conversion to Type W is ongoing. However, like Factory B, it is possible to absorb Japanese type management by teams and creates a team and which possesses diversified autonomy that does not exist even in Japan.

Thus, when imitation of, or conversion to, Type J would advance in the future as a result of diffusion of the present Lean Production System, it is anticipated that factories would be gradually divided into two groups: Type S + J where the role of ME expands, and a similar type to Type S + W, where the position of ME is not established.

5-3-4 Advantages of Swedish Type

In Sweden, what causes the motivation to convert to type J? There could be various reasons including remarkable rationalization and improvement of production found in Type J. In fact, the Swedish type has the forte shown by Type J. A case example we should pay attention to is Swedish Factory B, which proceeds in a new direction while imitating TPS.[9]

Factory B shows the achievement of the Swedish type, and it could be a case example to be referred to in the future. The advantage of the Swedish type shown by the example of Factory B is "self-controlled autonomy." This direction has the advantage of playing the role of eliminating waste = loss in terms of company management. The experience of Factory B is important when considering advantages of the Swedish type.

6 Closing Remarks-Japanese Unique Division of Production and TPS

The characteristics of the Japanese-style division of labor shown in Type J, which is currently diffusing overseas, is considered to have inherent properties that cannot be obtained through conversion from other types. The inherence shown by Japan is possibly connected with the basic characteristics of TPS established in the context of Japanese-type corporate structure.

First of all, a manufacturing engineer that shows the characteristics of Japanese division of labor is an engineer's position inherent in Japan, and the role of manufacturing engineers strongly reflects the management philosophy of Taiichi Ohno, the father of TPS. Ohno put emphasis on manufacturing engineers as field engineers. As the basic structure for

9 In 2010, IFMetall's new policy spells out a new direction to enhance the competence of individuals and strengthen the duty assignment = duty position (befattning) of the labor side regarding the operation organization as the base for their power. It is a thoughtful practice to be based on expansion of duties done by each operator and to respond flexibly to production-related changes demanded by the management side.

factory management, he employed such a management method that makes manufacturing engineers strategically address reduction of labor and facility cost in cooperation with teams.[10] The Japanese-style three-level division of labor materializes Ohno's idea on engineers' function and approaches. The characteristics of the manufacturing control approach that support the competitive power unique to Japanese companies are found in the overlap of waste elimination based on the manufacturing engineering, management of the standard operation, and teams. The organizational structure that supports this approach is Type J's three-level structure and fostering and assignment of human resources bearing manufacturing engineering.[11]

Thus, without manufacturing engineers and teams, waste elimination and operation management in Japanese companies cannot be achieved. With the two-level division of labor that lacks manufacturing engineering in Western companies on using Type W, Type J cannot actually be attained, even though the team function is introduced.[12] Among many of the Western companies taking pride in introducing Lean Production System, the position of manufacturing engineers has not been established yet. In almost all cases, the division of labor at the manufacturing worksite of the companies adopting Lean Production System is actually nothing more than the two-level division of labor.

Manufacturing engineers are in the position to integrate the knowledge and perspective about operations assumed by teams, as well as the knowledge about production facilities, and understand the actual conditions of manufacturing that materialize such knowledge as the production process and work contents (Tamura [2021]). The position of manufacturing engineer stands in the middle of both engineer side and operator side. By forming this middle position, production organization could obtain a quite important place for information exchanging and regulating activities among mechanical, operating and engineering parts for solving problem and innovating production itself. It takes time and experience, and strategy to form such a job position systematically.

Japanese employment practices based on long service, called life-long employment, are very beneficial to build this middle overlapping area between engineering and operating. It would be difficult to transfer this position to overseas countries where employment practices are different. Such kind of overlapping position, we should say, is a result of the Japanese organizational activities accumulated historically (See, Ohno's activities in footnotes 9). That is why Type MJ

10 The Ohno Line at Toyota in 1950' is the origin of the functions of manufacturing engineering. (Wada [2009] See p. 312 and subsequent pages). In order to advance Toyota's production restructuring, Ohno allegedly recognized the need to know automobile structure and composition as well as values of parts precisely. "How much is the cost of an actually produced automobile and the cost of labor?" As the targeted points for rationalization of a manufacturing company and the starting point for management of engineers, the overall production should be reorganized by grasping labor in the manufacturing process. This is the essential turning point in the production management system of TPS.

11 As for the relation between manufacturing engineers and operator groups in Sweden from historical point of view, see Tamura [2008]. In this paper, manufacturing engineer are supposed to be stemmed from time study engineer, "arbetsstudieman" or "tidsstudieman" who not only checked and set motion time with time study devices, but also solved problems concerning works and coordinated conflicts between operator and management, see Berner (1988), and these points are argued in relation to Swedish Model by Giretz (2008), Tamura (2019).

12 As for the relation between overseas deployment by Japanese companies and manufacturing engineers and the recognition of Ohno about manufacturing engineering, see Tamura [2011].

(Modified Japanese Type), a three-level division of labor type modified from the Japanese original type, has emerged. In Type MJ, the team function is virtually weakened, ME and production engineers are integrated, and the managing function is enhanced (Tamura [2010], [2011]) .

In the future, Swedish organization structuring could develop along the Lean Production Type modeled on Japan. At the same time, it cannot help but develop while being affected by the structure of division of labor that the conventional Swedish type teams have always had.[13] Supposedly, the relation of responsibility sharing between teams and engineers will advance, and between the Lean-oriented direction and Sweden-oriented direction could be integrated in different level along the DX development. It has the possibility of developing into not only wasting elimination and reducing cost by Lean tools, but also causing to preparing a new direction forward DX on the LPS concept and tools different from the Japanese one. The present conditions in Sweden, I think, have set the stage for the new generation of Swedish type management style, as we could recognize some trials and examples at "Smart Factory Lab" in Scania. Such a future development and trials called "Industry 4.0", "Smart Factory" and "Smart Industry" in Sweden, which show important experiences for Japanese management as well.

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(Revised 26 October 2022)