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I Introduction

In recent years, many Japanese firms get much success in the factory management. What makes them so successful? Do they take advantage of the sophisticated scientific management techniques? Perhaps this question will get the negative answer.

On the contrary, they god rid of such techniques as ones based on EOQ concept. Their priciple is to use the wisdom for improving the production process instead of the analytical method[3]. Concretely, their objectives are the minimization of the inventory, zero defects, balancing the process and so on. They made autonomize the production process using the information tool or KANBAN. This is comparable to the autonomic nervous system of the human body. The just in time production system was attained by those series of their efforts. In quality control, they attained extremely low failure rate as well as the excellent quality product.

As is presented by the word, wisdom, the cultural tradition has a significant role. In this paper, the cultural difference is considered through the work models which give the starting point of our approach[7]. Based on these models, the principles for Japanese production system represented by Toyota system is reviewed and compared with Western counterpart.

Japanese production management system is generalized as pull system, while American one is push system represented by MRP(Material Requirements Planning). The difference between these systems comes from the style of control. MRP is controlled by centralized administration extensively dependent on the computer system. On the other hand, control in Japanese system depends on human system which has the decentralized configuration. The difference of function between these two systems is discussed in terms of work models and culture.

II Production management in Japan

Japan is the country filled with the homogeneous tribes. This ethnic unity has developed the work system characterized by the groupism. On the other hand, US has the big ethnic diversity and their work systems are characterized by the individualism. In Japanese firms, most jobs are done by the groupism way. They have many things in common and get to consensus easier.

The difference in management style is rooted that of work custom or tradition. So it may be reasonable to initiate the comparison from the models of the way of work. The way of work has something to do with the culture, the way of thinking, life style and so on. American takes over the tradition of materialism and rationalism originated in Westerm Europe and the analytic methodology is their main tool for thinking.

On the other hand, Japanese basically have no such a scientific tradition but the empirical rationalism tradition succeeded from Confucianism. This one is

characterized by the holistic way of observation and thinking, and has built into Japanese mind. Western science and technology have been imported and developed successfully on this framework.

We call the Japanese model of work as model J and that of American as model A. The difference in work systems is clear-cut when compared by their real case, and work model. As the matter of course, all Japanese do not always take J model way and same is the case for A model. These two models should be taken as the extremes between which most ways of work exist.

model J

At first, they set the goal and make the project get into run without finishing an overall complete plan. They intentionally make confront with problems only after they take the concrete forms. The problems that surely come up in running the project are resolved ad hoc at that emerging point. The basic reason to take this way of work is based on the idea that it is the time consuming work to make up a good overall plan. The uncertainty expected to be met in the process of project run are also difficult to forecast at the planning stage. Some techniques to resolve the problems under uncertainty are proposed from the scientific point of view. But, they desire to get into the project run without recourse to so called scientific management methodology that sometimes are misleading. They prefer the methodology come from their experience, intuition and skill.

The operational level people responsible for running the project have to be skillfull and trustworthy enough for this way of work leading to the successful result. The information exchange between the divisions or the members who take part in the project must be active and adequate. For this purpose, the groupism way of work system is more suitable which has the close personal communication network.

Instead of analytical methods, the empirical and the intuitive ones play the bigger roles in model J. The intuitive inference which have the great flexibility are used extensively for solving problems and decision-making. This model of work can be called as that of thinking with running which characterize the way of Japanese work system.

model A

Various steps necessary to attain the clarified goal are examined analytically and programmed with the schedule and the counter plans for the kind of issues expected to come up. The project is progressed according to this program and the particular work is started when program reaches its starting point. The actions to the issues are also forecasted through the scientific methods. The intuition which plays the big role in model J has only a small room to take part. The operational people are not expected to be so reliable and the program is designed for every member to take only has part alloted in the project.

The personal exchange of information between workers also does not bear such a big meaning. The supervisor responsible for the project controls the progress of it and also makes arrangement between divisions.

Problems which come up in the process of running the project, are resolved according to the counter plans given by specialists. They also are responsible to resolve the problem which do not be expected in the initial plan. Specialists are people who have

the scientific knowledge as well as the intuition derived from the many experiences of solution of the same kind of problems. They take their parts in special or divided problem solving instead of the workers which are usually taken by the workers in model J. In addition to this, the synthesis of the divided project works is needed in the final stage of the work. This process gives the birth to the area called as Systems Engineering.

In summary, project is treated in holistic way, and the intuition and the tight personal information network plays the big role in model J. On the other hand, scientific analysis and synthesis characterize the model A. In work process, specialists for the specialized area are required in model A, while the generalists who take the holistic judgement are required in model J.

Ⅲ Comparison between Japanese and American Production Systems

Ⅲ. 1) Toyota Production System

The creator of Toyota Production system,Taiichi Ohno of Toyota co. sometimes mentioned that the meaning of the next two equations are different in its nature, even if they seem same at first look[4].

$$(\text{Price}) = (\text{Cost}) + (\text{Profit}) \quad (1)$$

$$(\text{Profit}) = (\text{Price}) - (\text{Cost}) \quad (2)$$

This could not be grasped from the rationale of model A view point. He continued that eq. (1) represents the cumulative system in which the total cost comes from cumulative sum of the partial costs and the price is determined by adding the secured profit. In this way, management of production only strive to observe the old standard, which is an orthdox way in scientific management. But the price might run out of competitive edge easily and also the production has many chances to fail to adapt to the changing environment. This shortcoming comes from the fact that old standard can not be good one for so long time.

Alternatively, eq. (2) means profit has to be secured to the appropriate level under the competitively determined price. The cost of production has to be cut down to attain this price. They tried and made up many devices in the production process, which comprise Toyota Production system in total.

The quality of products also has been improved through the quality control circle which makes the workers quality oriented. Quality problems are resolved at the point of production, so that most of the independent quality control divisions are abolished. Their basic strategy is to build the quality into the product at the earlier stage of production.

Ⅲ. 2) Development of the Autonomous System

Toyota's first step for building up their own production system was to cut down the inventories existed in many places of their factories to a minimum number. The materials in the inventories take many forms such as the parts, semifinished products and finished products, etc., which comprise the buffers between production points. They occupied large spaces in the shop and sometimes became obstacles for shop management. Large costs were also consumed for maintenance and chance loss, which amount sometimes were not negligible for the company.

Toyota made up the well known JIT (Just In Time) system to get round these problems. JIT also resolved the problem of balancing the production rate among

divisions and work stations. This system is accomplished through the KANBAN system which enables the production line to be the autonomous one and processes the multi-products that characterize the automobile industry. The production system also contains many newly developed devices such as the single set up press machine, fool proof system (Bokayoke), the indicator of conditions of work station (Andon) and so on.

Another their basic philosophy of production is to make all things clear and easy to see and to eliminate the sanctuaries, i.e., things or places which are given too much authority to treat easily. In some production processes, factory people are apt to make such exaggerated places around the precious machines or the elaborated in-process inventory facilities. The existence of these places makes generate so many of uncertainties in the process of design and control of production lines that the management for the operations on such lines gets many difficulties. Toyota people broke away such places from the lines and made all places easy to see.

They made up all of these systems and devices mainly by their wisdom, as they call, or mixture of intuition and long time experience without relying upon the sophisticated management science methodology. On the cotrary, they point out the failure of models and formulas developed by such methodology. For example, the formula for the optimal lot size is valid only under the very limited condition which rarely comes up in the real situations. As a matter of fact, the configuration of production system has been changed through the improvement of the system and become very flexible one, which can not be figured out by the so called mathematical model analysis. In many cases, the cost parameters considered in usual quantitative models are also subject to change and not easy to get the precise value. The minimal lot size fitted to the good production conditions is taken in JIT system.

Another important strategy in Toyota system is to make a unified smooth flow of commodities in a production process. They take even the production processes in subsidiary as ones connected with their factories and unified into one assumed production line. Their main object to attain this unification is the balancing of production process and minimum lead time is secondary one. They coordinate the divisions in a production line and prohibit the partial divisional runs of breaking the overall production balance. This kind of regulations is very easily performed in J model company by the groupism way. Anyway, they can reach to their consensus promptly.

Ⅲ. 3) Autonomization of the production process

In the notion of Toyota system,"Making the autonomous flow through the line"is the most important object, which means the autonomization of production. At the final stage of process improvements, production process can be an autonomic one comparable to the autonomic nervous system in the human body as mentioned earlier. As the production proceeds autonomically on such a production line, the special production scheduling is not needed except the loading program at the first production station.

This system need the close contacts between production stations, which is one of the characteristics of the Japanese organizations. As is cited by many authors, corporate members have the implicit understanding for each job which they got in the process of planning commonly.

In the model A type firm, each work station is separated from other, so the intentional effort is needed to get the good inter-sectional communication. Instead of making personal network, they made up the intensive central administration system using computer system which make the compulsory flow of jobs and communication.

Ⅲ. 4) Japan-US difference in Quality Control

In quality control, the scientific model A teaches that the failure probability p of process is estimated from the past operation records and used for the process control through the statistical quality control. They take the analytical approach and consider the failure due to "unassignable causes", which means uncontrollable failure by any human efforts. The theory based on mathematical statistics is used to explain this event. This concept is not wrong in itself, but the theory is too specialized for line workers to get the real meaning. They are only required to observe the routines given by the specialists. So, the QC in model A firm has become a specialist work separated from the line workers. This separation sometimes develops the assignable "unassignable causes", which could give the unnecessarily higher failure probability.

But, in model J firm, they pursue the cause of failure more completely, without admitting the concept of unassignable cause, and have attained the very low failure probability measured by ppm(part per million), too small value to use statistical methods. This approach to quality problems, as mentioned earlier, makes the line workers more quality concern and even give a kind of artisan spirits. This kind of QC environment has been realized through TQC or QC circle activity. On the other hand, in model A, the sophisticated analytical methods and formalism in QC could become big obstacles to resolve the quality problem.

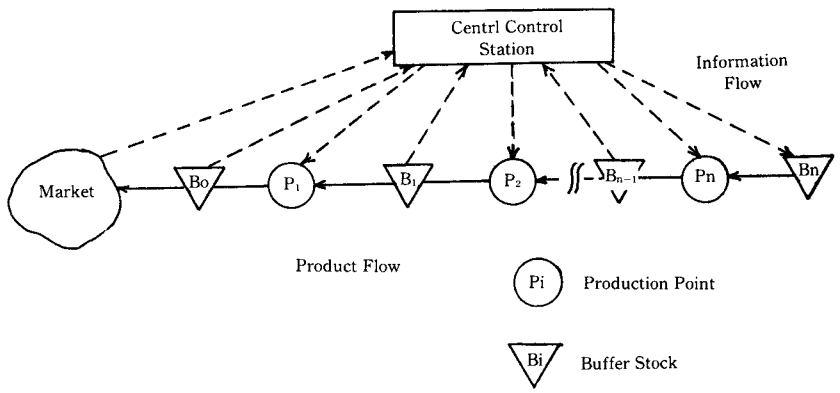

Fig.1 MRP System

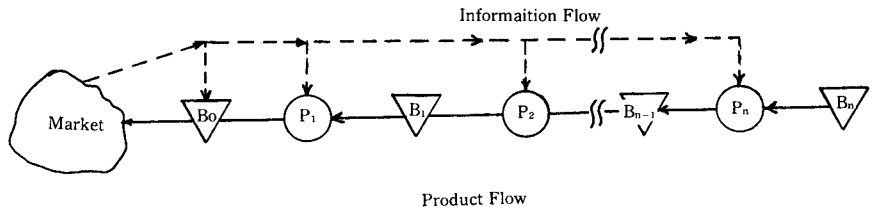

Fig.2 Toyota System

IV Push and Pull system in the production

In the factory management, usually 2 control channels are considered to exist. One of these is the central control system, and another one is the communication among work stations. These two kinds of control channels are shown in Figs. 1 and 2. Usually, any production process has these control channels and it depends upon the policy or culture of the firm which one they use as the main way of production control.

In US, MRP system has been developed which utilizes the central control configulation. On the other hand, Toyota system has been created which emphasizes the in-process communication. In MRP system, a central control station(center) manages the production process according to the logically made up master schedule. The actual results of job performance are fed back to the center which is compared with the master schedule and the appropriate revision for master is made. MRP treats the work stations as the independent ones and does not put so big weight on the human relation in work group. The real time management system is built up through the computer cotrol, which realizes the job control using the concept of time backet. A time backet gives a set of jobs processed in the same time period. In MRP system, Jobs are loaded on the production line one after another from the first station, which seems to push the jobs into a production process. Hence, the name of push system is given to this type of production system.

For Toyota system, the control basically relays upon the work station and its relation to another station, i.e., KANBAN system. This situation is shown in Fig. 2, in which the solid line gives the material flow and the dot the information flow, i.e., KANBAN flow. As the information flow is supposed to pull the in-process product from the former station, this kind of system is named as the pull system. This type of communication and control is adequately suited to J model company. The information flow in the network among work stations of the well organized Toyota system is sometiomes comparable to the electric currents in the good conductor like a copper wire. The production systems in subsidiaries are also closely connected to their lines through JIT system using KANBAN. So, their group of production systems is assumed to constitute one whole big system.

V Improvement oriented process control

One big reason why J model company does not use the so called scientific methods comes from the fact that they continuously strive to improve their work systems and quality. For a goal of continual quality and process improvement, most of the usual concepts of SQC and production control must be reviced, because these ones contain obedience of the one fixed standard, which contradicts with the improvement orientation. The first step in scientific approach is to observe the real situation and make up the standard based on the observation. The concept of standardization is very valuable, but the standard should not be fixed. In Toyota system, they do not think their standards can be good ones for such long period. There exists many kinds of causes to obsolate these values, because workers get the expertise soon and also make improve thier work method. This kind of improvement including that of quality is established as one of the daily activities.

On the contrary, in scientific method, established standard is required to keep as the best one way unless some special changes come up. This thought is valid for the natural

phenomena, but cannot be good for human activities of evolutionary feature. As this is case with the work system, the scientific methodology is not supposed to make much contribution to the work study. In Toyota system, they always strive to change their work standard so often by introducing many devices that their standards may not be called as "standards". As an example of this kind of device for production line improvement, they present the concept of conveyer line work different from usual one of conveying works through the work line. Their notion for conveyer is the work tool which makes up a work system.

For line balancing, they do not use a unique solution to balance line, but set a tentative standard cycle time, around which it takes variable time. Workers can change the cycle time by stopping the line using the switch at their work stations. When line stops, the indicator called ANDON notify its place and cause. This kind of work system is able to make troubles in the line clear up through line stop. The basic thought of this method of line balancing is to resolve the problem ad hoc way and coincides with that of J model.

In J model system, they permit no fixed standards, but changeable ones and their engine for change is summerized as the improvement. The improvement can be said to be the most important among J model disciplines.

As an another example, we take the EOQ model for inventory control to show the inflexibility of the mathematical model. In the simple form, minimization of inventory cost is formulated as the trade off between order and holding costs. This kind of model has many shortcomings, in spite of their apparent scientific style. Above all, basic concept of inventory is now changing to trend to cut it, but we could not use this model to find the new concept. So, we have to be careful, for this kind of approach is unable to give new trend. Secondly, the parameters and constants involved in these models are supposed to be estimated from the past data. But this kind of data is not useful from the improvement oriented point of view. In addition, some of them often are very hard to estimate, because the model fails to match the real situation. These models are partly effective to explain the mechanism, but not applicable for practical purpose. Toyota people have made up completely different paradigm for inventory control, i.e., zero inventory.

This paradigm is also valid for the FMS or the future production system that has no need for buffer or inventory. The set up time has been shortened drastically by many kinds of devices, which makes the production flow smoother. Their production system involved these kinds of devices can be transfered to the automated one directly if they judge this transfer is reasonable. But the automation suffers from the emphasis on the structured mechatronic system that loses the flexibility and improvement orientation. Therefore, the decision for automation must be critical one.

VI Conclusion

For the comparison between US and Japanese industrial management, we focused on Toyota and MRP as the key production system from both sides. This decision is supposed to be reasonable. Because now the many firms use these systems. The main caracteristic of culture of J model consists in the groupism, while that of A model individualism. This sort of contrast seems to be quite common, but this framework constitutes the essential part of comparison. Some issues come up from this comparison.

The first one is why and how the culture can be related to the type of production system. We can consider many kinds of relation agents, first of which has been shown to be the style of communication in the organization. J model firms have the tighter personal communication, which enable them to take the personal network as the main channel. On the other hand, A model may take the central system, because of their individualism.

The second has something to do with the way the work is progressed. That is called push or pull system according to the relation between information and work. The pull system is concluded to fit to the J model firms, while the push the A model. We got this conclusion from the cultural difference.

The third is about the improvement orientation. In this relation, we showed the so called scientific methdology is apt to give the inflexible results. The improvement orientation is among their main paradigms. TQC gives the motive force for the improvement in product and system.

Although we criticized the scientific methodology, we will require the real science to attain the further breakthrough. This kind of science must be able to get many things from the experience and wisdom, and cover the improvement paradigm.

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