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〔研究ノート〕

General Overview of Assembly Automation and Future Outlook of The Production system.

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The early 1990's have witnessed a major transformation in the production system of the worldwide automobile industry.

The development of automation technology has provided the impetus for change to the production system and work organization of the automotive factory in all major auto producing countries over a period of 70years as the cornerstone of mass-production industry based on the continuing moving assembly line.

Especially, apparent has been the dramatic process of automation in the automotive factory working processes such as casting, body assembly, painting the area in which it has been relatively easy to move to automation.

However the greatest bottleneck toward automation has been the final assembly line. It has been common issue for world auto makers how to develop the automatization of this stage of the work process which is highly labour intensive and thus creates many problems in organization of work.

But through the development of automation technology ; eg. the development of many types of robots, self control devices, and information management system technology such as C.I.M. ; the automation of the final assembly line in which a higher level skillfulness and judgement has been needed and has thus been considered unsuitable for automation. There are many differences among countries, and even among individual auto manufacturers in same country, in the way automation has been introduced as well as the rationale for it. For example, some companies like Volvo and some Japanese auto makers, the main motive has been to make a more humanized assembly line and more attractive working conditions. In the case of the Japanese, generally speaking, their attitude toward assembly automation tended toward conservatism in the early stages. Later, however, it become a direct motive of strengthening automation that appeared as a result younger workers of the shortage and the declining rate of employment in the late 1980's. In this case, however, there has been a mixed motive at work. One was to promote reduction in the number of man hours through automation in order to respond directly to the perceived labour shortage. The other was to prepare for a structural shortage of young workers in the late 1990's through shortening working hour and making a more humanized work place for them. Western auto manufacturers' on the other hand tented to concentrate on eliminating the number of workers needed parallel with ensuring quality stability through assembly line automation, and they emphasized the use of automation devices as a hardware aspect and aimed at reducing the number of unskilled work forces on the assembly shopfloor.

Although these differing motives still exist, the process of further assembly line automation is still going on among automobile factories in the industrial countries. But if

we look at the process of automation development and evolving factory production systems, we can find significant differences among individual manufacturers and within different factories of the same makers expressed through differences in the strategies for promoting automation as well as differing production systems used by each manufacturer. An important question to ask if these approaches will continue to diverge, or are simply temporary, and will eventually converge as the standardized model of an optimum automation system in the future? Moreover if we assume that it will converge, will it to do so as a single model or multiple model based on difference premises for automation?

Eventhough from early in the period the 1980's to 1988 when assembly automation boomed worldwide, Japanese car manufacturers tended to be conservative in introducing automation into their assembly line except for areas such as stamping, welding, painting and so on.

On the other hand, among European auto markers such as VW and Fiat, for example, tried more aggressively to develop assembly automation, and as a result the automation ratio among European marker was generally higher than among their Japanese counter-parts. Among U.S auto manufacturers there was a contrast between those more eager toward assembly automation and more conservative ones. For example, GM's Hamtramuck or Linden plants started with higher automation levels from as early stage, Whereas Ford's Chicago and Atlanta plants tended to be more conservative in strengthening automation taking a step by step approach, while waiting to enhance development of skill levels by their shopfloor workers.

Above all during the late 1980's there was a clear contrast between Western auto makers who were eager to induce assembly automation, and more prudent Japanese maker.

In more recent years, however, that contrast has diminished, in terms of the ratio of automation because the assembly automation boom has taken hold among Japanese auto makers as a response to the labour shortage.

During this process, however, the question of what kind of production system is best suited has emerged as the most critical issue in strengthening assembly automation.

In general terms there are two main paradigms for the production system : High volume mass production system which was traditionally dominant in U.S and Europe, and the lean production system which was developed mainly in Japan.

During the 1980's a consensus was reached that there is greater flexibility and productivity with high quality in the lean production system once expanded to the worldwide base, which reserved in this system paradigm being transferred internationally in various patterns. In this case these has emerged a dramatic difference in the operating way of production system between two extreme paradigms. One way is based on a system of subdividing working practice and to respond by monotonous job content, and the other to attach more importance to worker's multi-skillfulness, to simplify job classifications, and to promote team work through QC circle activities and Kaizen. Thus in introducing higher assembly automation there are two approaches, whether to preserve the high volume mass production principle, or whether to establish lean production system through the assembly automation process.

In this dichotomy, it is remarkable to discover among some western auto makers who

were ahead on assembly automation, considerable reflection on the usefulness of too much expensive automation with a mainly hardware orientation toward maintaining the high volume mass production system. After all, if they invest totally in automation equipment and attempt to operate it, they cannot always ensure a stable operation as before.

They have experienced many cases of difficulty of quick response and prevention of trouble in the production process.

Therefore, in some of the automated western plants there are increased efforts to find new way of automation through a step by step approach to change to a lean system. There are apparent efforts to consider a way of automation through reforming traditional working practice such as monotonous worker domination, intricate job structures along with reconsidering the training system for shopfloor worker.

Recognizing that these trends exsit as mentioned above, if we consider more generally the assembly automation issue now and in the future, we can raise a number discussion points as follow :

(1) How can we understand the apparent diversity of strategies on assembly automation?

The diversity of strategies for automation are compounded by international differences and diversity within the production system. Even in one country, manufacturer's strategies for assembly automation differ among individual auto makers. It is reflected in the difference of process design in the assembly line which are connect with the approach they take forward of product design and parts procurement.

For example, almost all auto manufacturers introduced robots for their assembly plants in step such as installing batteries, tires, instrument panels, bumper, pouring oil, window glass attachment and so on. These process are relatively amenable to automation and have a more obvious rationale from the viewpoint of eliminating heavy work and working mistakes. But with respect to some process as such as assembling hood and trunk or engine installment, some makers are very hesitant to introduce automation because it requires higher precision to ensure sequence continuity. Further more there are many different way for the use and introduction of robogate or AGV depending on their manufacture.

Recently the use of multi axis and multi dimension robots is increasing as a way to improve performance and functionality. performance and reliability by use of devices and equipment such as T.V, Camera, Sensor, and A.I, (Artificial Intellegent) which are replacing human functions of seeing, hearing, and perceiving etc. The Highest reliable complete automation would be difficult if they couldn't achieve improvement and uniformity of total precision back to the up-stream production process. Until now, one major reason why automation in the assembly line in Japan was delayed was the fact that the reliability for high tech devices such as robot, sensor, and A.I. was inadeavate.

Furthemore, even if they became more reliable, it would be impossible to operate flexible assemble line production systems without the ability to respond quickly to abnormal trouble and situation changes in the assembly line production process by multiskilled workers. Compared with the Japanese case, Fiat's Cassino plant tries to keep it's operating ratio with a number of vehicle buffers besides the automated zone. Japanese plants, in general, don't keep such buffers and therefore has to ensure a high level of reliability and

maintenance capability for automated equipment, making multi-skillfulness all the more important. Even in Japanese plants there are differences and special character in terms of how they can use multi-skillfulness relating to their process design.

(2) What then of the relationship between the type of automation and skillfulness, judgement capability by shopfloor worker, and expectancy or reliability toword T.P.M response by them? It is natural that the shopfloor worker's Kaizen capability still often needs the advanced automation? They couldn't introduce automation without matching higher skill levels, judging capability and reliability for T.P.M response capability?

Are there way of putting it : Are there any ways to advance automation at first, and then to expect enhancing skillful and learning capability of shopfloor workers as a new challenge? If so, what about the role of management side, such as the role of production engineers and foremen.

(3) What about the relationship between automation and work humanization, labour shortage, response for shortening working hour, and production flexibility? Can a system of flexibly responsive automation which is necessary for Kaizen and participation by shopfloor worker, match with the requirement for automation to respond to work humanization, labour shortage, and shortening working hour? How can the need for flexibility be combined with automation?

(4) How do we relate the process of product design with the process of assembly line automation? How do we coordinate the process of design to suit automation through modulization and the way of developing the product concept? Which way is best suited for mutual check and cooperation between R.&D. and production engineering department?

(5) How do we make an appropriate choice between Kaizen accumulated automation and total system-styled full automation?

It may be the ultimate direction of assembly automation to move towards totally unmanned lines such as assembly lines for Cameras, VTRs, and semiconductor etc. Yet in considering unmanned lines, there are several different images. One is the image of eliminating direct worker involvement on the assemble line through complete unattended line, the other is the line which is backed up by shopfloor workers and talented engineer who have the human skills and judgement capability, also software of skillfulness, and maintenance know-how transferable to robots. Perhaps, the biggest dilemmas to pursuing unmaned assemble line is as follow. It seems risky, that unmanned line tend to exclude multiskillful worker who have been keeping maintained until now, and also tend to weaken their growth potential. Thus we may find it most important that unmanned line is only the result but not as an objective in and of itself. Therefore, knowledgeable-skilled workers, who have been educated in the use micro computer software including multiskillfulness, and also have a supporting capability for expert systems, and machine maintenance capability on the shopfloor level, should remain the master of the unmaned line.

Through such an understanding we will confront two choices. Do we make the automation which accumulate Kaizen as a process for developing multiskilled workers into knowledge-intensive skilled workers. Or do we pursue total system automation focusing on the rapid advance of high-tech automation technology? These two approaches don't necessarily provide a clearcut alternative, however. Even among Japanese auto

manufacturers there is no consistency but rather difficult choices in the way they select the process for promoting automation.

(6) In sum, by promoting assembly automation, we are confronting alternative approaches. One way is that more expensive investment automation will be used for the long term in considering it as the advanced investment.

The other way is to accumulate incremental automation matching optimum production volumes with lower costs. In the former case with expensive automation, the big issue is reliability of high-tech automation and responsive capability by assembly shopfloor worker.In the later case problem tend to be realized by the availability of lower cost high-tech automation in future assembly lines.

(7) What kind of impact on assembly line automation is likely to be seen by pursuing a restructure strategy, such as decreasing the number of car types, commonization of parts, component and platform? This kind of issue is most pertinent for recent experiences of japanese auto makers.

These efforts at cost cutting through restructuring will likely have the effect of simplifying the content of automated work. It may provide an opportunity to mature the advanced investment automation.

(8) Changing contents of flexible production and future prospect of assembly automation.

Until now flexible production has been related with changing structural ratio of number of output in car categories and car types version under the constant scale volume, and with quick response toward car model change. The urgent task from now is that future assembly line automation must be able to respond to changing product categories with changing lot production and small lot production, if production volume are likely to decrease with total changing demand. There are critical issues of how we can make possible available assembly automation which is respondable to volume flexibility.

(9) Are there any implications for the process of automation due to changing product development strategy in the near future?

If product concept and model change cycle will be change in the future in accordance with changing customer needs, environment, safety and recycling problems, will it be possible to keep the extension of the way of traditional assembly automation? Don't we need a new product concept identity by each maker as to what kind of product concept they should emphasize?

These nine discussion points are only my suggestions based on what I found it through my research on Japanese assembly plant automation. In closing, let me summarize as follow. In which direction should we seek the basic paradigm for the future outlook of production system? How do we think about the principle of labour practice and work organization accompanied with automation? How do we view future of automation technology including C.I.M and automating production system? How can we grasp relationship between future automation product concept and automation?

The Motive Assembly Automation

The Way of advancing Automation and Way to develop the Production System

Optimum Automation System < Converge one standard model / Diverge multiple model

Pursue Higher Final Assembly Automation Ratio from Early Stage
(Example GM Linden)

More Prudent Higher Automation Ratio with Step by step Approach.
(Example Ford Chicago)

Two Paradigm of Production System { High Volume High Speed Mass Production System / Lean Production System

Which is a lead < Radical hardware introducing Automation Approach / Lean Production Approach

1. How can we understand apparent diversity of contents and motive of the assembly automation.

Easy to introduce robotization process. { Tire / Bumper / Battery

V.S.

Differentiating to robotization process by each maker. { Engine instalment / Assembling Hood and Trunk / Robogate, AGV.

The reliability of automation equipment.

V.S.

Responding capability of multiskilled workers.

2. What then of the relationship between the type of automation and skillfulness, Judgement capability, TPM response capability?
Which is ahead automation or skillfulness and capability.

3. What about the relationship between automation and work humanization, labour shortage, shortening working hour, and production flexibility?

4. How do we relate the process of product design with the process of assembly line automation?

5. How do we make an appropriate choice between Kaizen accumulated automation and total system-styled full automation?

6. Expensive investment automation V.S. incremental automation.

7. Impact on assembly line automation by pursuing restructure strategy.

8. Changing contents of flexible production and future prospect of assembly automation.

9. Are there any implications for the process of automation due to changing product development strategy in the near future?