ROLE OF PRODUCTION SIMULATION FOR HUMAN ORIENTED PRODUCTION SYSTEMS

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ABSTRACT

Present factories have been aiming at realizing fully automated production processes, however, factories with human workers/craftsmen will be increasing also. It is required to develop the management method to fulfill both the effective utilization of production facilities and the working satisfaction of them. This paper introduces the management architecture for autonomous production systems and explains how to assign jobs in such systems. Autonomous production systems are similar in decision making procedure for accepting given jobs in each controller to the production systems with human workers/craftsmen. Technological subjects are mentioned in this paper that are required to apply the architecture of autonomous systems to such human oriented production systems.
Keywords: Production scheduling, Simulation, Human-oriented, Autonomous, Working satisfaction

1. INTRODUCTION

Factories have been aiming at fully automated production processes, and consistent information processing through CAD/CAM to flexible automation systems. However, Japanese industries have constructed factories in abroad, especially in south-east Asian countries, where human workers play the main role in production.

On the other hand, industrial products are required more added values that also requires the craftsmanships on products by skilled labor. It is necessary, taking the above circumstances into consideration, to develop the management method to deal with both the effectiveness of automated facilities and the working satisfaction of human workers and craftsmen.

Craftsmen select the desired jobs by various measures, and the measures are changing by the situation where they are standing. It is difficult to set up the measures in advance. At each time when the job is given, the real time condition of the craftsman concerns not only with the measures of working satisfaction but also with what the craftsman is interested in, that leads the decision whether the craftsman accepts the given job or not. This precess is simular to the decision making process of each intelligent controller in the distributed production systems (Okino, 1992)(Ueda, 1992)(Arai and Amnuay, 1995).

This paper points out the considerable items when the architecture of autonomous production systems is applied to the human oriented production systems mentioned above. The production simulation plays the very important role in such systems that is also dealt in the paper.

2. AN ARCHITECTURE OF AUTONOMOUS PRODUCTION SYSTEMS

One feasible architecture of autonomous production systems is constructed using a kind of active database system, which is a connection of network system and database system (Arai *et al.*, 1996). The database consists of cell database and job database. Production scheduling is executed in a centralized way. Cell database stores present and future forecasted both cell and AGV ability, and the status is reported from the cells and AGVs.

The job database stores the production requirements of how many and what parts are to be machined, and present status of each work. The computer network connects these components. The total architecture of

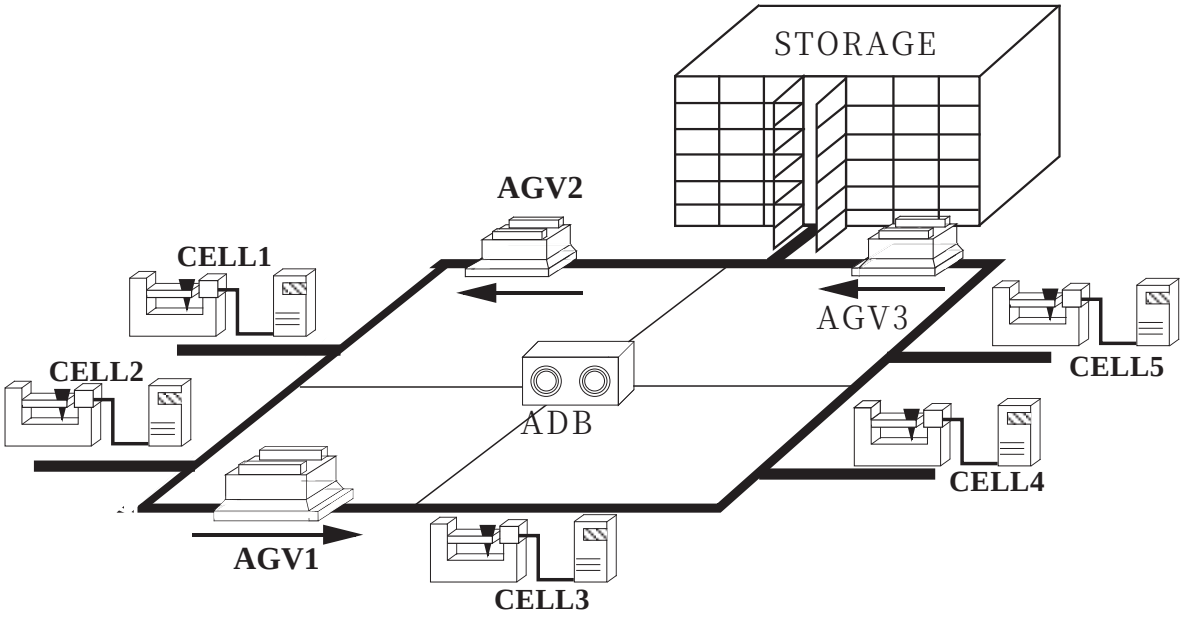

Fig. 1 Concept of simulation system for centerized and distributed MS

the system in shown in Fig.1.

There is another important element in the system that is the triggers to run the system. The active database can be elaborated when the triggers occur. Three types of triggers are considered ; the first is the change in production plan that comes outside the database, the second is the alternation in cells or AGVs such as failures and recoveries, the third also comes from cells or AGVs such as evidence discrepancy between the estimated machining/transportation time in the scheduling system and the cell/AGV.

Figure 2 shows how the actual task takes place when triggers occur. First, the active database sees the job database and picks up the unstarted processes. Then, cells are selected for each of processes. It must be clear that cells are assigned processes according to their abilities which is stored in the cell database. Busy cells are also omitted by selection. Each process is delivered to the selected cells each of them develops the operation plan to estimate the machining time. The estimated machining time by each cell is transmitted to the active database. After sometime the gathered information is send to the scheduling system to generate the production schedule. Because trigger will occur frequently in the actual factories, and re-scheduling loads will be heavy, simple rule is adopted here in the scheduling system.

3. AN EXAMPLE OF PRODUCTION SCHEDULING

A production system with five machining cells and three AGVs is taken as an example for more apprehension. The abilities of cells stored in the cell database is shown as Fig.3. When production requirement as Fig.4 is given, production schedule shown in Fig.5 is generated. Operation schedule of AGVs is shown in Fig.6.

4. TECHNOLOGICAL SUBJECTS FOR APPLICATION TO HUMAN ORIENTED PRODUCTION SYSTEMS

Each cell can select the desirable machining processes (works or jobs) by changing the ability in the cell database. The machining time estimation for each process is executed in each cell, that enables also the cell to select the desirable processes. The above proposed architecture for autonomous production systems can be applied to the human oriented production systems from these viewpoints where the craftsmen select the desirable jobs by various measures. However, the production schedule is generated by taking only the machining time into consideration, and it is required to develop the following technological subjects in order to apply the architecture to the human oriented production systems.

(1) To define working satisfaction of human workers/craftsmen

Evaluation of factory operation concerns with total running cost and utilization, of each machine/cell. Instead of utilization, the working satisfaction of each worker/craftsman should be taken (Kate and Kahn, 1978). The measures of satisfaction include ;

- comfort
- challenge
- financial awards

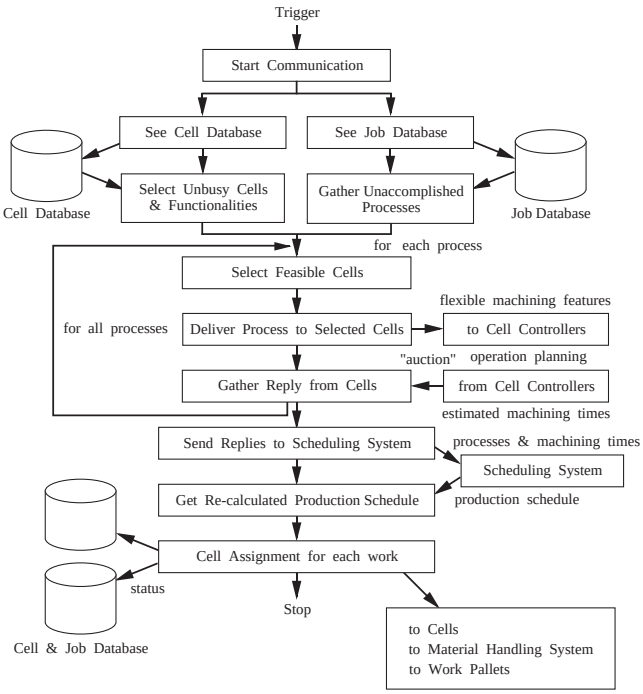

Fig. 2 Process flow raised by trigger

- relations with co-workers
- resource adequacy
- promotion

and others. Financial awards can be so considered that each cell (worker/craftsman) replies the production cost including awards to the given process before the cell assignment by the scheduling system. Relations with co-workers can also be considered for each cell to see the job database of process data and to get the scheduling result. If cells do not want to accept the scheduling result (cell assignment), they can send triggers to the active database for re-scheduling.

It is required to define the total working satisfaction including all other measures and to realize the mechanism fro each cell to select the job according to the measures.

(2) To improve the ability based on experience

Human workers/craftsmen are able to improve their abilities based on experiences, that is the difference from automated facilities. They accept jobs when jobs are interesting enough to improve their abilities. Too much easily accomplished jobs will be rejected, and jobs with problems to be expected to solve are hard enough to some extent will be accepted. They want freedom to decide how to solve problems.

The decision making process for their job selection nor production ability improving procedure are

Number	Feature name	C.V. Range 1					C.V. Range 2					C.V. Range 3				
	Characteristic value	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
1	Through-Hole	～ 2					2 ～ 5					5 ～				
	Diameter	2.2	×	3.0	×	1.7	2.7	×	3.3	×	2.0	3.3	×	×	×	2.5
2	Blindhole	～ 2					2 ～ 5					5 ～				
	Diameter	×	3.6	×	2.2	×	×	4.0	×	2.5	×	×	4.7	5.0	2.8	×
3	Pocket	～ 5					5 ～ 10					10 ～				
	Width	2.2	×	4.2	×	×	3.6	×	4.5	4.2	×	4.2	×	5.0	4.5	×
4	Shoulder	～ 5					5 ～ 10					10 ～				
	Width	×	4.5	×	3.5	2.5	×	5.0	×	4.2	3.0	×	5.3	×	4.5	×
5	Chamfer	～ 5					5 ～ 10					10 ～				
	Width	6.0	3.5	4.0	×	4.2	7.3	4.2	4.5	×	5.0	7.8	4.6	×	×	5.3
6	Channel	～ 5					5 ～ 10					10 ～				
	Width	3.8	4.2	2.2	×	×	4.4	5.0	3.0	×	×	5.1	5.3	3.3	×	×
7	Slot	～ 5					5 ～ 10					10 ～				
	Width	×	×	×	5.8	4.2	×	3.3	×	6.7	5.0	×	×	×	7.0	5.5
8	Plane	～ 5					5 ～ 10					10 ～				
	Width	6.2	×	3.8	×	×	7.3	×	4.7	7.0	×	7.8	×	5.0	×	×
9	Joint or Divide	～ 5000					5000 ～ 100000					100000 ～				
	Volume	61	×	83	111	167	61	×	83	111	167	61	×	83	111	167

Fig. 3 Machining cell data in ADMS with ADB

Work No. (Emergency flag)	Part ID (Volume)	Process No.	Sub Pro. No.	MF Type	(Dimension)	Precedence
1 (0)	1 (4000)	1	1	1	(3,20,0,0)	
			2	2	(4,8,120,0)	
	2 (4000)	2	1	3	(10,8,3,1)	⊃
			2	4	(13,11,4,0)	
	3 (4000)	3	1	5	(10,10,5,0)	
			2	6	(8,8,5,0)	⊃
			3	7	(10,7,4,0)	
	4 (1000)	4	1	8	(15,7,5,0)	
	5 (2000)	5	1	1	(7,10,0,0)	
	1:2:3 (12000)	6	1	9	(12000,0,0,0)	
		7	1	2	(8,7,0,0)	
			2	3	(10,15,3,0)	
		8	1	4	(15,5,5,0)	
	1:2:3:4 (13000)	9	1	9	(13000,0,0,0)	
	1:2:3:4:5 (15000)	10	1	9	(13000,0,0,0)	

Fig. 4 Work data 1 in ADMS with ADB

not formalized. The observable evidence is only the result whether they accept the given jobs. The secret procedures are dealt as the autonomous processing in each cell (worker/craftsman). Production scheduling and job assignment is realized in a centerized way. Workers/craftsmen can change the measures of satisfaction and standards to select jobs both of them belong to the improvement of their decision making process based on experience. They can also change the production ability in the cell database which affect the job delivery and assignment.

5. ROLE OF PRODUCTION SIMULATION

The working satisfaction is calculated in each cell (worker/craftsman) referring to various measures that vary according to the real time circumstance of each cell. They can simulate the production activities, and calculate their working satisfaction. When the satisfaction is not fulfilled, they can change their own measures,

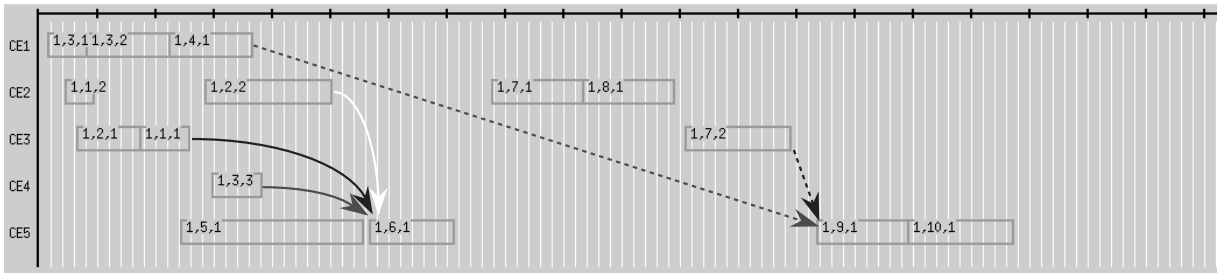

Fig. 5 Result of scheduling for first work

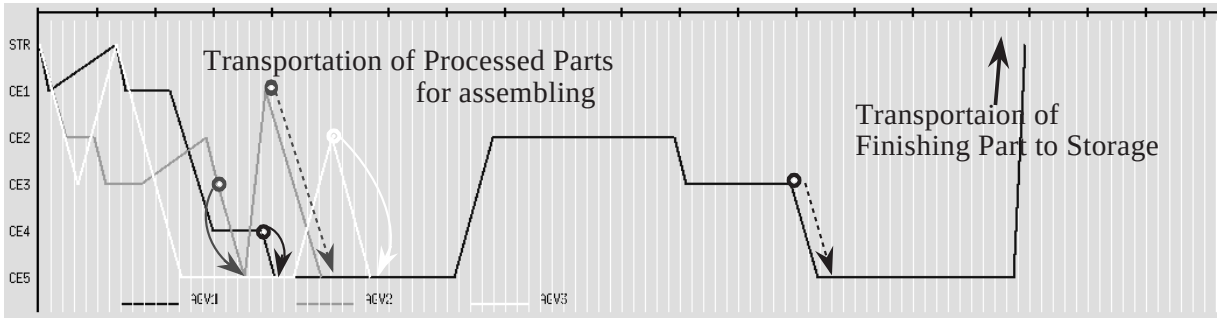

Fig. 6 Result of AGV scheduling for first work

interests, and production abilities in the cell database so that they get assignment of other sets of jobs. The working satisfaction is re-calculated according to the re-scheduled production simulation that uses the changed information. The change in one worker/craftsman may affect the job assignment of other people after re-scheduling.

Changes and re-scheduling are repeated until every workers/craftsmen satisfy the job assignment. It should be stated that there are no guarantee of getting the converged schedule that satisfies all people. Production simulation plays the very important role there. The requirement to simulation and scheduling softwares is as follows.

First is they should be fast rather than exact to get the solution, because they are so repeatedly used. Second is the easiness to change the information of measures, interests, and production abilities.

6. CONCLUSION

The production activity in the human oriented production system with human workers and craftsmen is executed due to each person's expectation of working satisfaction. Measures and interests for it can not be pre-defined, and the behavior of the system is similar to that of autonomous production system.

The management system architecture for autonomous production systems is introduced that uses the active database system, although there are several technological subjects to be developed especially so that job assignment, meet their working satisfaction. It is another important subject haw to improve the production ability based on each experience.

The role od production simulation is a very important tool so that each person selects the decision making process for given jobs to maximize his/her working satisfaction.

REFERENCES

Arai, E. and Amunay, S. T. (1995). An Approach to Flexible Cell Assignment and Dynamic Scheduling in FMS. *Systems Control and Information*, Vol.39, No.10, pp.549-556.

Arai, E. *et. al.* (1996). Auction Based Production System through Active Database System. In: *Proceedings of the Pacific Conference on Manufacturing*(PCM'96), pp.371-375.

Kate, D. and Kahn, R. L. (1978). *The Social Psychology of Organization*, John Wiley & Sons.

Okino, N. (1992). A Prototyping of Bionic Manufacturing System. In: *Proceedings of Int. Conference on Object-Oriented Manufacturing Systems*, pp.297-302.

Ueda, K. (1992). An Approach to Bionic Manufacturing Systems Based on DNA-Type Information. In: *Proceedings of Int. Conference on Object-Oriented Manufacturing Systems*, pp.305-308.