Human Oriented Production Management Considering Working Satisfaction

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ABSTRACT

Even in an advanced factory, human workers or craftsmen have been required to achieve highly flexible and skillful production. This paper introduces the management architecture for human oriented production systems. The proposed architecture includes two technologies; one is the communication network in the factory using the active database system, and the other is the dynamic scheduling method to consider the workers' satisfaction. The active database system gathers the real-time information on the shop floor and delivers the on-going schedule to workers in order to get their response for dynamic scheduling. The management architecture proposed is required to fulfill both the effective utilization of production facilities and the satisfaction of workers or craftsmen.

Keywords: human oriented, production management, active database, dynamic scheduling, working satisfaction

1. INTRODUCTION

An advanced factory has been sophisticated to enhance the efficiency and flexibility in production by integrating CAD/CAM/CAE systems, automated facilities and so on. However, the CAD/CAM/CAE systems are predominant over the automated facilities, and the control information to the facilities should be generated previously by the CAD/CAM/CAE systems. Therefore, a conventional flexible production system has no way to adapt for a disturbance, such as sudden change of production plan and trouble of facilities happened in real production processes. In order to solve this problem, a distributed production system based on "auction" concept is introduced [1].

On the other hand, human workers or craftsmen have been required to achieve highly flexible and skillful production. In these circumstances, working satisfactions should be given to the workers or craftsmen, and a newly management architecture to consider the working satisfactions is required. In this study, it is assumed that the workers select desired jobs according to their valuation and satisfaction changing by their feeling and situation. It means that the decision whether the worker selects the assigned job or not is unpredictable. The process that the worker selects the desired job is similar to the decision making process of each autonomous cell organizing the distributed production systems [1, 2, 3].

In this paper, the management architecture for human oriented production system which fulfills both the effective utilization of production facilities and the satisfaction of workers or craftsmen is proposed. In the proposed architecture, the workers correspond to the autonomous cells, and every worker can select his/her jobs and change his/her working hours dynamically according to his/her valuation and satisfaction. Furthermore, the system based on a distributed production system can generate the newest production order using the dynamic scheduler and maintain the continuous production against a disturbance such as sudden change of production plan and trouble of facilities.

2. PRODUCTION SYSTEM ARCHITECTURE

The system architecture proposed in this study is shown in Fig.1. A kind of active database is a integrating network system and database system is used to construct a feasible architecture of autonomous production system [4].

The core part of this system is the active database which consists of a communication controller, a cell database and a job database. The cell database stores the ability of workers, cells and AGVs that is forecasted in present and future, and the status that is reported from workers, cells and AGVs. The job database stores the production requirements of how many and what components to be produced, and the present status of each job or operation.

In surrounding part, a scheduling system and CAD/CAM systems are connected to the core part. Human workers and autonomous cells are connected also to the core part through GUI controllers and cell controllers, respectively. Detailed information of products is defined by the CAD/CAM system using machining or assembling features with process constraints. Ability of workers and cells is characterized by the machining or assembling features treated and their performance.

The active database delivers the messages to exchange information among workers, cells and AGVs to manage distributed manufacturing when triggers occur. Four types of triggers are considered; one is the change of production plan that comes from outside of the active database, next is the workers' requirements such as working hours and taste, the other one is the alternation in cells or AGVs such failures as and recoveries, the last one is the discrepancy between the estimated operating time for the scheduling system and the actual one for the workers, cells and AGVs.



Fig.1 System architecture with active database



Fig.2 Process flow of dynamic scheduling

3. PRODUCTION SCHEDULING

A production plan is given to the active database as a trigger. The active database stores the production plan, which consists of the representation and number for each products in the job database, and delivers it to the selected workers or cells that are feasible for the required operation of each product referring to the cell database. Estimated operating times for the required operations are replied to the active database from the workers via the GUI controllers and the autonomous cells via the cell controllers. A bunch of the estimated operating times corrected is sent to the dynamic scheduling system to deliver the operations to the suitable workers and cells.

The process flow of dynamic scheduling is shown in Fig.2. When a trigger occurs, the active database searches the job database and finds the unstarted operations. Then, the workers and the cells that are feasible are selected for each operation. The workers and the cells are assigned to the operations according to their abilities stored in the cell database. Each operation is delivered to the selected worker or cell, and each worker or cell estimates the operating time. The operating time estimated by each worker or cell is gathered by the active database. The gathered information is send to the scheduling system to generate the newest production schedule. The scheduling system assigns the suitable worker or cell for all operations under the condition to satisfy the shortest production time.

4. HUMAN ASPECTS

The first consideration of human aspects is the working hours of each worker. Working hours consist of normal hours and extra hours. Extra hours provide the better commission rate to workers.

The second one is the financial award. Usually, workers get salary partially by fixed income and partially by the commission to the working results. In order to get more salary, they must work harder and the extension of their working hours is one solution. They can declare their working hours independently according to their life style and expecting salaries. The scheduling system assigns the jobs to the workers during their working hours, and shows the expected salary to the workers. Every worker can negotiate with the system to select their jobs dynamically according to their working satisfaction. But, the working satisfaction of each worker is different each other, therefore it is impossible to generate the optimized production plan which gives the working satisfaction to every worker.

The third one is the friendship with co-workers or the taste for the jobs. A good relation with their co-workers makes good working environment, and the working ability is improved. The other hand, a bad relation with their co-workers makes their working ability worse. The taste for the jobs affects the working ability, too. A good feeling to the favorite job results in good productivity and quality. The working ability affects to the operating time and the production schedule.

The last one is the progressive skill. The skill of each worker depends on his/her experience to the jobs. The inexperienced workers have to be trained by the skilled workers through their co-operation. Actually, the productivity of the production system decreases because the skilled worker is disturbed by the co-operation with the inexperienced worker. But, their co-operation is needed to train the inexperienced worker and to keep the traditional skill for the production system.

The distributed production system starts to run according to the original production plan or schedule, while the workers can send the trigger to the system whenever they want to change the working hours. When the trigger occurs, the active database starts to re-generate the production schedule referring to the working hours and the working abilities that are updated. The negotiation time which is required for the re-generation of the production schedule is estimated. All jobs that would start within the negotiation time are assigned to the original workers to avoid the discontinuous of the production.

Another worker who wants to change his/her working hours can send another trigger to the system. Chains of triggers generate the modified production schedules, but these schedules are not guaranteed to be converged where the working satisfaction is given to all workers.

5. CASE STUDY

Figure 3 shows the original production schedule and the workers' award. In Fig.3 (a), the small rectangles with numbers show the assigned jobs, and the short vertical lines show the start/end of the workers' working hours. In Fig.3 (b), the workers' awards corresponding to their salary are shown as the points estimated. When the worker corresponding to the cell #5 wants to get more salary after a while he/she starts working, he/she can send the trigger and declare the extension of the working hours which results in the new schedule shown in Fig.4. The workers' award of the cell #5 increases from 850 to 1150, that causes the decrease of salaries of other workers. Especially, the worker's award of the cell #4 decreases from 722 to 622. After this rescheduling, the worker corresponding to the cell #4 can send trigger and declare the extension of the working hours to keep his/her salary. Of course, other workers can send the triggers to keep their working satisfaction.



(b) Workers' award corresponding to their salary

Fig.4 Rescheduling results generated by request from worker #5



(a) Scheduling result unconsidered workers' friendship Job assignment to satisfy workers' friendship



'Job assignment to satisfy workers' friendship

(b) Scheduling result considered workers' friendship and improving ability **Fig.5** Improvement of production schedule caused by workers' satisfaction









In the scheduling result shown in Fig.5 (a), the workers' friendship is not considered. In the scheduling result shown in Fig.5 (b), the workers' friendship is considered. In this case, the successive processes are assigned to the workers who have good relation each other. The workers' friendship has higher priority than the productivity to generate the production schedule. Furthermore, it is assumed that the good working environment improves the working ability 1.5 times higher. It is clear that the total production time becomes short. Also, the quality of products will be improved. It is difficult to estimate the working ability, but the good results will be obtained under consideration of the workers' satisfaction.

Figure 6 shows the scheduling results in which the co-operative jobs performed by the inexperienced worker and the skilled worker are considered or not. In the result shown in Fig.6 (a), the co-operative jobs are not considered, and only one job is assigned to the inexperienced worker corresponding to the cell #5. In the result shown in Fig.6 (b), the co-operative jobs are considered, and the skilled worker corresponding to the cell #1 trains the inexperienced worker through their co-operation. In the result shown in Fig.6 (c), the progressive skill of the inexperienced worker is considered. In this case, it is assumed that the progressive skill makes the working ability 2 times higher after the several co-operative jobs.

6. CONCLUSION

In this paper, the management architecture for human oriented production system which fulfills both the effective utilization of production facilities and the satisfaction of workers or craftsmen is proposed. The proposed system is running as the centralized and distributed production system, and it generates the newest production schedule dynamically to consider the workers' satisfaction. In this system, a machine trouble, a machine repair and a change of production plan are notified as the triggers to generate the newest production schedule. Similarly, a change of working hours and a workers' disagreement are notified as the triggers, the workers can get the newest production schedule when they want to get their satisfaction. Although the regenerated production schedules are not guaranteed to be converged where the working satisfaction is given to all workers, the proposed management architecture give the opportunity to change the present schedule when the workers feel unsatisfactory.

Technological subjects still remain, however, the human aspects should be considered in the future flexible production system.

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