PRODUCTION SCHEDULING AND MANAGEMENT OF INDUSTRIAL PRODUCT BASED ON COMPUTER SIMULATION TECHNOLOGY

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ABSTRACT: The production planning and scheduling is the core issue of enterprise management, which is directly related to the production efficiency of the enterprise. Taking the production of mold as an example, this paper aims to study the production scheduling and management methods of industrial products based on computer simulation technology. For this, the coding problem, crossover operator and mutation operator of genetic algorithm (GA) were designed, and a production scheduling model based on improved GA was also proposed. Meanwhile, computer simulation technology was used to simulate the virtual workshop environment of the mold production. Based on this, the simulation analysis was performed for mold production scheduling method based on the improved GA. The research results showed that compared with the traditional scheduling method, dynamic production workshop scheduling method based on the improved GA can more effectively improve equipment utilization and working time utilization, and enhance the production efficiency to a certain extent, which indicates the importance of information-based management in the production scheduling of industrial products. The research findings enrich the theoretical research results for the production scheduling and management of industrial products, and have certain practical significance especially in the mold production scheduling.

KEYWORDS: computer simulation technology, production, scheduling, management

1 INTRODUCTION

The manufacturing industry is the basic industry of the national economy. With the advent of global economic integration, the manufacturing model has undergone tremendous changes, while it's also been faced with dynamic market policies, fast-changing market environment and customer needs, continuous replacement of product varieties and batches, and rapid update of new technologies (Offodile and Abdel-Malek, 2002). Thus, the traditional labor management method is difficult to effectively control the manufacturing process of industrial products. The use of computer information management is the inevitable choice of industrial product manufacturing enterprises to improve production efficiency and management level.

The manufacturing planning and scheduling of an enterprise are directly related to its production efficiency, which is the core issue of enterprise management. The development of human

manufacturing industry has generally gone through several stages: traditional manufacturing models of universal machine tools, special manufacturing systems, flexible manufacturing systems and reconfigurable manufacturing systems (Wang et al., 2007). The reconfigurable manufacturing system is the main direction of the current manufacturing development. Under this system, enterprises can quickly respond to the market and win competition, but it puts forward higher requirements on the production shop scheduling of the enterprise. The operation plan of workshops is exposed to problems at any time such as urgent order entry, completion of processing tasks ahead of schedule, machine failures, task delays, and raw material shortages. Therefore, the shop scheduling has the characteristics of complexity, multi-objectives, randomness, and constraints (Harrold, 2001). Scholars have proposed many methods to solve shop scheduling problems, including mathematical programming methods, knowledge-based scheduling methods, rule-based scheduling

methods, simulation scheduling methods, and local search methods, etc. (Sung, 2008). In recent years, some scholars have applied artificial intelligence, physics, biology, and other theories to the shop scheduling problem (Chen and Fu, 2001), and achieved certain research results. Among them, chaos search, evolution strategies, and GAs, etc. are mainly studied (Nimmanonda et al., 2004). Due to the dynamics and complexity of the production shop scheduling problem, as well as the increasing scale and difficulty, a single mathematical model and scheduling technology fail to obtain the optimal solution to this scheduling problem (Liu and Huang, 2015).

Based on the above, the authors attempt to apply computer simulation technology to the production scheduling and management of industrial products. Firstly, this paper describes related computer simulation technology and production scheduling problems of industrial products. Then, taking the production of molds, the basic technological equipment of industrial products as an example, it proposes a production scheduling model based on improved GA, and establishes a virtual mold workshop environment through computer simulation technology. In this simulation environment, a simulation analysis was performed on the production scheduling of molds based on improved GA. The analysis results verify the effectiveness of the mold production scheduling method based on improved GA. This also indicates the importance of information-based management in the production scheduling of industrial products.

2 RELATED THEORETICAL BASIS

2.1 Computer simulation technology

Simulation is the uses of models to study the behavior of a system through simulation of real things or processes (Shambu and Suresh, 2000). Computer simulation refers to the use of computer modeling and simulation technology to dynamically simulate and replay the system for obtaining quantitative indicators of system characteristics; the data obtained can often provide corresponding reference for future decisions (Tu et al., 1992). The system mentioned above includes social, physical, and natural systems (Ponnambalam et al., 1999).

2.2 Production scheduling

Production scheduling is the use of the enterprise's existing equipment and raw materials to rationally deploy the processing order of products based on the production schedule, in order to improve equipment utilization, reduce the processing cycle of products, and meet the production needs of the enterprise (Kozak, 1998). With the market changing, people's individual needs continue to increase, and the production scheduling problem gradually develops toward integration, dynamics, and high intelligence. The traditional scheduling methods are mostly static scheduling, i.e., it's assumed that materials, machine, and job processing time, etc. are all determined. But in the actual scheduling process, many problems occur randomly, and there exist unpredictable disturbances in scheduling tasks. Therefore, dynamic scheduling has become a research hotspot. Following the development of computer technology, new methods such as particle swarm optimization, GA, and neural network technology have emerged continuously, providing new ideas for the research of dynamic scheduling in manufacturing.

3 SIMULATION ANALYSIS FOR INDUSTRIAL PRODUCT PRODUCTION SCHEDULING BASED ON COMPUTER SIMULATION TECHNOLOGY

3.1 Production shop scheduling method based on GA

3.1.1 Description of dynamic production shop scheduling problem based on GA

The problem of mold production scheduling can be described as the processing of jobs with n different processing operations on m machines. Each job should follow one production and processing sequence in the production process; each job is processed on each machine in different processing sequence, and each machine can be used no more than once. Let c_i and S_n be the completion time of jobs i and n, respectively, then the ultimate goal of production shop scheduling is to minimize the maximum completion time, i.e., $\min f(S_1,S_2,\ldots,S_n)=\min\{c_i\}$.

It's assumed that M is the machine set, $M=\{m_1,m_2,\ldots,m_m\}$; P is the job set, $P=\{p_1,p_2,\ldots,p_n\}$; OP is the set of processing order, $OP=\{op_1,op_2,\ldots,op_{im}\}$; op_i is the processing order of the job p_i; T is the time matrix of each job on one machine; m_j is the j-th machine; p_i is the i-th job; op_{ik} is the machine number used by the i-th job in the k-th process; t_{ij} is the time of the i-th job p_i on the j-th machine.

3.1.2 GA-based production shop scheduling method

Most genetic algorithms belong to static scheduling, without considering the changes of

tasks and resources. In order to optimize production scheduling to the maximum extent, and determine the parts and machines to be processed in real time, the authors changed the relevant operations and time corresponding of real-time task and machine status to dynamic data, and extended the static scheduling to dynamic scheduling.

(1) Encoding the scheduling problem

In this study, a hybrid coding method (based on a mixture of processes and lists) was used to encode the production shop scheduling problem based on GA. Assuming that 3 jobs are to be produced on 3 machines, the processing time of jobs 1, 2, 3 is [3,3,2], [1,5,3] and [3,2,3] respectively, and the chromosome coding method is [(2,3,1), (1,3,2), (2,1,3)], that is, the chromosome is divided into three segments, which represent the processing orders of the three jobs on the three machines m_1, m_2, m_3. The first segment (2,3,1) indicates that the priority processing order of the three jobs on the machine m_1 is job 2, 3, and 1. Figure 1 shows the Gantt chart of production scheduling for 3 jobs on 3 machines.
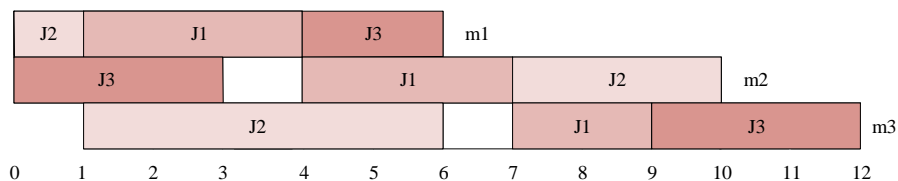

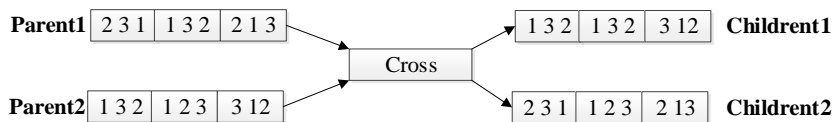**Fig. 1 Gantt chart of production scheduling**

**Fig. 2 Crossover operator implementation process**

(2) Operator design and overall structure of improved GA

Crossover determines the global search capability of the GA. In order to ensure the feasibility of the offspring and its ability to inherit the excellent characteristics of the parent generation, this paper proposes a new crossover operator based on hybrid coding. Figure 2 shows the implementation process of the crossover operators for scheduling problem (the three jobs on three machines). This method realizes the priority sequence that the offspring inherits the parent machine, retaining the priority sequence of all jobs on machine 2.

Fig. 3 Mutation operator algorithm flow chart

In order to search and improve the performance of the offspring in a local range, this paper uses a mutation operator based on neighborhood search. The specific process is shown in Figure 3.

The expanded sampling space was adopted to improve the traditional GA, which not only ensures the diversity of the offspring, but also retains the optimal chromosomes to the next generation, thereby effectively improving the scheduling speed and quality. Figure 4 shows the specific process of the GA improved for the scheduling problem of mold manufacturing:
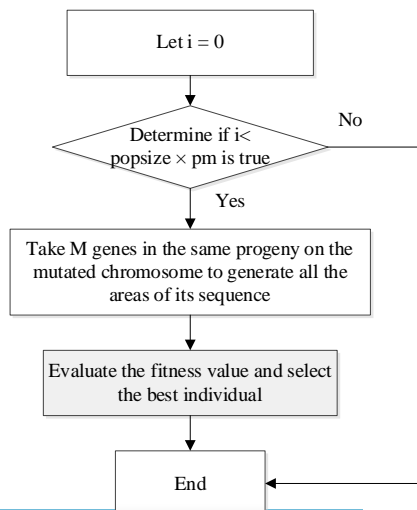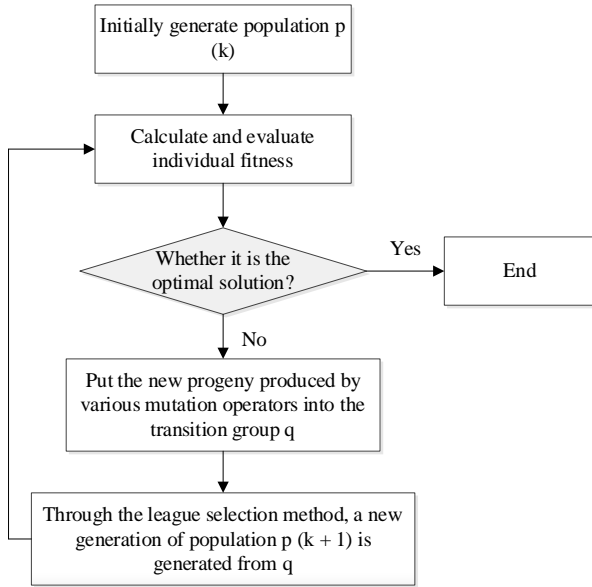
Fig. 4 Improved genetic algorithm process

(3) Determining the fitness function

To schedule the mold manufacturing in a timely manner, this paper establishes a fitness function model as follows:

In Equation (1), T is assumed to be the processing time matrix of n molds on m machines in order to express the time relationship between different processes. And a process constraint matrix was also required to constrain the process on each type of mold, as shown in Equation (2):

$$T = \begin{pmatrix} t_{11} & t_{12} & L & t_{1m} \\ t_{21} & t_{22} & L & t_{2m} \\ L & L & L & L \\ t_{n1} & t_{n2} & L & t_{nm} \end{pmatrix} \quad (1)$$

$$M = \begin{pmatrix} m_{11} & m_{12} & L & m_{1m} \\ m_{21} & m_{22} & L & m_{2m} \\ L & L & L & L \\ m_{n1} & m_{n2} & L & m_{nm} \end{pmatrix} \quad (2)$$

Among them, the processing time of the *i*-th mold in the jth process is indicated by t_{ij}, and the *j*-th process of the i-th mold processed by a certain machine is indicated by m_{ij}, $m_{ij}=1,2,3,…m$.

In addition, the constraints of the gene being decoded required the judgement for calculating the start time and end time of each process. The calculation model is shown in Equations (3) to (6), and the target model is shown in Equation (7).

$$C_{js}(i, j) = \max \left\{ C_{jt}(i, j - 1), C_{mt}(i - 1, j) \right\} \quad (3)$$

$$C_{jt}(i, j) = \max \left\{ C_{jt}(i, j - 1), C_{mt}(i - 1, j) \right\} + t_{ij} \quad (4)$$

$$C_{ms}(i, j) = \max \left\{ C_{jt}(i, j - 1), C_{mt}(i - 1, j) \right\} \quad (5)$$

$$C_{mt}(i, j) = \max \left\{ C_{jt}(i, j - 1), C_{mt}(i - 1, j) \right\} + t_{ij} \quad (6)$$

$$Min(Max\, C_{mt}(i, j_t)$$
$$i = 1, 2, L \ \ n; \ j = i = 1, 2, L \ \ m \quad (7)$$

where, j_t is the last process of mold *i*; $C_{js}(i,j)$ and $C_{jt}(i,j)$ are the start and end time of the j-th process of mold i; $C_{mt}(i-1,j)$ is the time from jth process of the mold i to the end of the process; $C_{jt}(i,j-1)$ is the end time of the mold *i* in the *j*-1th process; $C_{ms}(i,j)$, $C_{mt}(i,j)$ are the process start and end time of the machine that the jth process of mold *i* operates on, respectively.

3.2 Virtual simulation of industrial product production scheduling based on computer simulation technology

According to the actual mold production, this paper establishes a dynamic environment model of the mold production shop using QUEST simulation software. Figure 5 shows the environment model of virtual production line. The computer simulation technology was also applied to simulate the production line for 4 hours through the mold production scheduling method based on improved GA, and then perform analysis for related data.

Fig. 5 Virtual production line environment

Fig. 6 shows the analysis results of equipment utilization rate. Fig. 7 shows the results of working-hour utilization rate. It can be seen from the figures that compared with the traditional scheduling method, the improved GA-based dynamic production shop scheduling method can more effectively improve the utilization rate of equipment and working hours, and promote production efficiency to a certain extent.
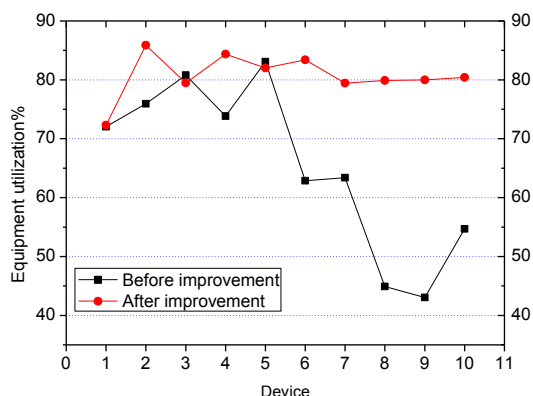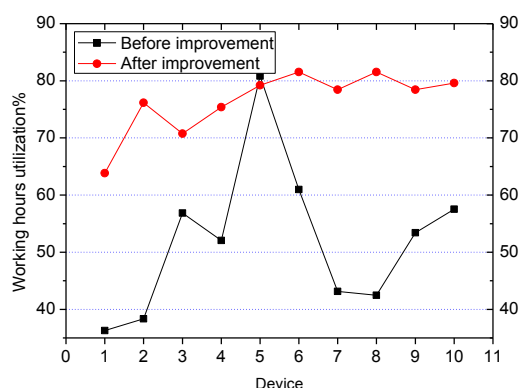
127

Fig. 6 Equipment utilization

Fig. 7 Working hours utilization

3.3 Information-based management of industrial product production scheduling

In order to adapt to the increasingly fierce domestic and foreign market competition and users' demand for product diversification, manufacturing enterprises of industrial product should strengthen the information-based management of production scheduling, improve equipment utilization and resource utilization under reasonable scheduling, and produce a variety of products simultaneously according to the different needs of customers in the shortest time. In this study, the combination of computer simulation technology and production scheduling method based on improved GA greatly improves the equipment utilization rate and working-hour utilization rate of mold, and indicates the important role of information-based management in production scheduling. Therefore, in order to improve the production management level of industrial product manufacturing, it's necessary for enterprises to establish a production management system or platform that meets their actual production needs.

4 CONCLUSIONS

Production scheduling is the command center for the operation of an enterprise. The quality and efficiency of production scheduling are directly related to whether an enterprise can win users and markets. This paper, taking the production of molds as an example, studies the production scheduling and management of industrial products based on computer simulation technology. The specific conclusions are as follows:

(1) To solve the problem of mold production scheduling, the authors designed the coding problem, crossover operator and mutation operator of GA in detail, and proposed a production scheduling model based on improved GA.

(2) Computer simulation technology was applied to simulate the virtual workshop environment of the mold, and analyze the mold production scheduling based on the improved GA. The analysis results show that compared with the traditional scheduling method, the dynamic production workshop scheduling method based on the improved GA can more effectively improve the equipment utilization rate and working-hour utilization, and promote the production efficiency to a certain extent.

(3) The simulation results further indicate the importance of information-based management in the production scheduling of industrial products. Thus, it is necessary for enterprises to establish a manufacturing management system or platform that meets their actual production needs.

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