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Research on planning scheduling of flexible manufacturing system based on multi-level List algorithm

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Abstract

In view of the complex structure of flexible manufacturing system and the difficulty of production planning, A general flexible manufacturing system scheduling model is built, and a List algorithm based on multi-level flexible scheduling algorithm is proposed as the core algorithm of general model. A general planning system is developed. The model and algorithm are analyzed and verified by the plan layout, and the correctness and adaptability of the model and algorithm are proved.

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Keywords: FMS; List Algorithm; Program Schedule;

1. Research background of flexible manufacturing system planning schedule

To improve the production efficiency of multi-variety and small batch production mode has been a hot issue in the research. Many varieties, small batch processing means in form of basic similar parts require frequent adjustment of fixture, Process stability is difficult to increase, production efficiency is bound to be affected. In order to solve this dilemma, flexible manufacturing system come into being[1]. Flexible manufacturing system is composed of a plurality of processing center or production unit to achieve a variety of production line. From the hardware structure, it can be divided into work units, CNC machine tools, demolition equipment. Workbench is responsible for parts of pre-folder, and lifts work units to the corresponding equipment clamp through the logistics transportation rail according to the plan instruction., The part of NC program is processed on the device when the workbench is sent to the device. After the processing is completed, the workbench will be sent out by the track of the logistics, and the parts are disassembled by the removing equipment. At the same time, the new clamped workbench will be sent to the equipment to continue process, The spare workbench will clamp the next processed parts into the buffer.

Automatic scheduling of production planning is one of the most difficult problems in the production management. At present, there are lots of related algorithms, which are aimed at production planning the mode of pipelining production and the discrete manufacturing mode[2][3][4]. However researches on scheduling of flexible manufacturing system are still less. Simple flexible manufacturing system automatic scheduling have implemented by Siemens and other flexible manufacturing machine control system vendors abroad, but the general scheduling model and algorithms for specific flexible manufacturing system with the mechanism have not been achieved[5][6]. In this paper, a general flexible manufacturing system based on multi-level scheduling model is established, and a general plan scheduling system for flexible manufacturing system is developed based on the algorithm. At last, the model and algorithm are verified by the production scheduling of flexible manufacturing system.

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2. Multi-level scheduling model of Flexible Manufacturing System

In the task-resource model, the resource act as a carrier, each resource needs to carry a number of tasks, and make sure that the task on each resource is not clashed.

Three hierarchical sub-models are inherited from the master model. The task and resources are generalized in the main model, and the three-level sub model is formed to support the multi-level scheduling model of the flexible manufacturing system. Three hierarchical sub-models are processing task-workbench model, workbench-machine model, workbench -disassembly equipment sub-model.

(1) Processing task-workbench model means multi-scheduling models performed parallelly. The task in queue is arranged to a number of work stations to achieve loading and clamping. The specific tasks here is clamping tasks, working platform is the resource.

(2) Workbench-machine model means the parallel scheduling model of multi-machines. The task of clamping on the working table and the working table is arranged to processing on a plurality of machines, this procedure is called processing task scheduling. The specific task here is the workbench and clamping task, and the resources are processing machines.

(3) The workbench-disassembly equipment sub-model, means the parallel scheduling model of multiple disassembly equipment. The finished processing tasks scheduled to be demolished on multiple demolition equipment, names demolition task scheduling, The specific task here is the workbench and the processed tasks, resources are demolition equipment.

Scheduling is parallel in each level of production due to the diversity of resources, But the three hierarchical sub-models have a sequence of serial relationships, which represent the three ordinal operation of the clamping, the processing and the disassembly. The first level of production is the initial state of the next level, and the end time of the task clip is the initializing constraint of the processing start time, machining end time is the initializing constraint of the demolition start time. Above all, three- scheduling model is serial on the whole, and parallel partially, as shown in Figure 1.

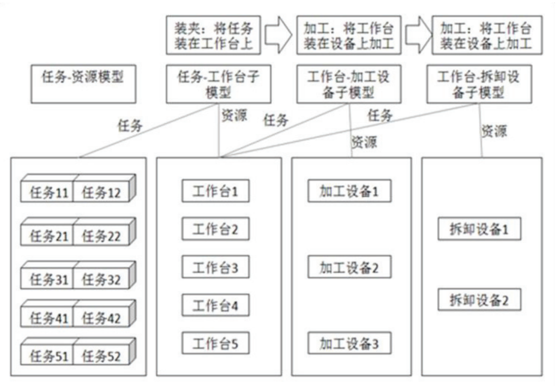

Fig 1 Scheduling model diagram

3. Multi-level list algorithm based on flexible scheduling model

List algorithm is a greedy algorithm which is based on a certain principle of optimality to achieve algorithm of local optimization.

3.1. List algorithm based on task-resource model

We assume that there are M kinds of tasks $MT = \{T_1, T_2 ... T_{m-1}, T_m\}$, N kinds of resources $NR = \{R_1, R_2 ... R_{n-1}, R_n\}$, the scheduling time for the task T_i is $[t_{i\_begin}, t_{i\_end}]$, the mission start time is t_{i_begin}, and end time of the task is t_{i_end}. The task queue is $\{T_1, T_2 ... T_P\}$, which is located on the resource R_j, and the earliest free time of the resource R_j is t_{p_end}.

Target of algorithm:

The task set MT arranged on NR according to the principle of the first end of the resource, so that the ending time of current scheduling is the minimal for each assignment, and make sure that the resources and tasks does not conflict. The algorithm flowchart is shown in fig2.

Algorithmic process:

(1) Set $k = 1$;

(2) Schedule the $k (k \le m)$ th task T_k. Firstly, call the resource to select the scheduling resource R_j of algorithm T_k, and then call the task working time algorithm to calculate the start and end time of T_k;

(3) if $k \le m$ set $k = k + 1$, turn to step one; otherwise exit.

3.2. Algorithm of resource selection

Target of algorithm:

In the current state (that the scheduling in $k-1$th task is finished), we select the resource R_j as the next resource for scheduling. The selection rule of resource R_j follow the principle of the earliest finished resource after the end of $k-1$th task. Resources' ending time is determined by the finish time of the last task on the resource. The algorithm flowchart is shown in fig3.

Process of algorithmic:

(1) Traverse all resources on the NR, each resource R_j has been scheduled for the task queue $\{T_1, T_2 ... T_p\}_j$, $j \le n$, $p \le m$, Get the tail task T_p, The completion time of T_p is t_{p_end}, which is the earliest free time for R_j.

(2) Traversal all resources on the resource NR, select the resource R_j which has the smallest t_{p_end}.

3.3. Algorithm of task time

Target of algorithm:

The starting time and ending time of the task is determined by the initial state of the current resource, the initial state and the working period of the task, and the resource calendar. The algorithm flowchart is shown in fig4.

Algorithmic process:

(1) Get the Resource ready time t_R by the initial state of resource, and get the earliest ready time t_P by the current task of resource, also we can get the task-ready time t_T by the initial state of task. So the start time of the task is the maximum of the three, namely $t_{begin} = \max(t_R, t_P, t_T)$.

(2) Completion time t_{end} of the task is calculated when t_{begin} is brought into the resource calendar.

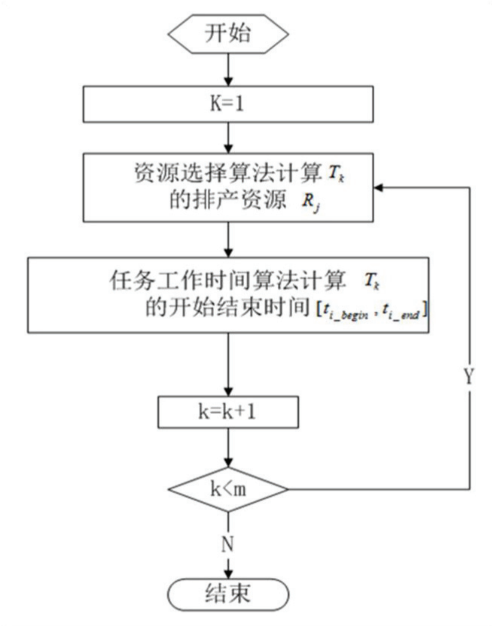

Fig.2 Algorithm flowchart

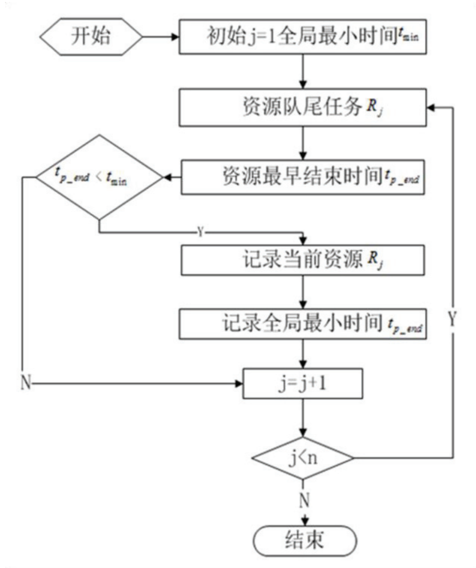

Fig.3 Algorithm flowchart

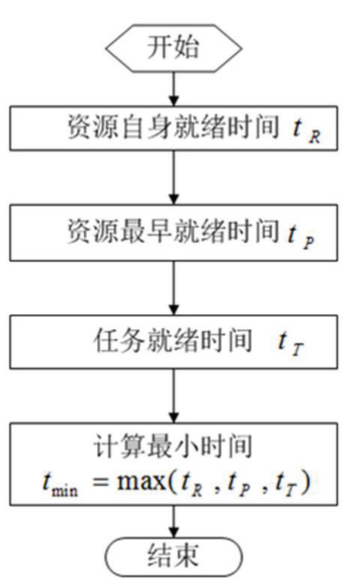

Fig.4 Algorithm flowchart

3.4. FMS planning schedule

In the flexible manufacturing system, the flexible manufacturing system is called "p-q-k" system if the total number of workbenches is P, the number of table processing equipments is Q, and the number of stage removal equipments is K. The task of $MT = \{T_1, T_2 ... T_{m-1}, T_m\}$ is required to be processed. Work can be concretized by the resource model, can achieve clamping, processing, demolition of the task respectively, and make sure that the workbench, processing equipment, demolition equipment does not conflict.

Implementation process:

(1) Clamping: Task-workbench scheduling means the task is scheduled on the table.

The list algorithm based on the task-resource model is used to arrange the multiple tasks on the workbench. Getting specific task-resources out can make tasks correspond to the real needs of machined parts, resources correspond to the table. So that we can get the sequence of clamping, the starting time and ending time of the task. The clamping of workbench can be divided into parallel-clamping and serial-clamping. as shown in Figure 5 and figure 6:

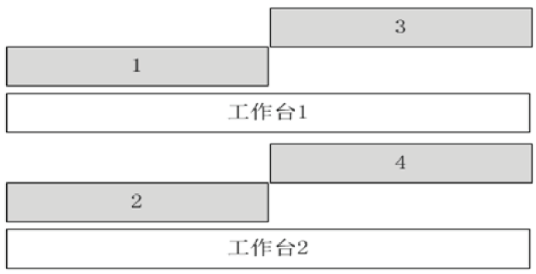

Fig.5 Multi-workbench parallel clamping

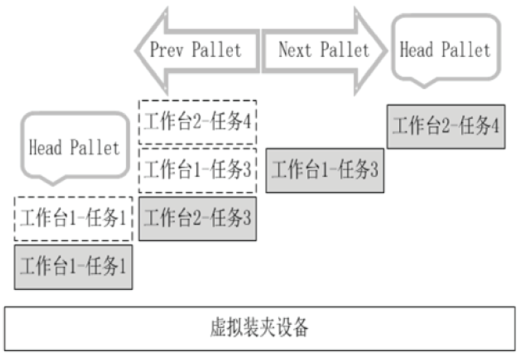

Fig.6 Multi-workbench serial clamping

(2) Processing: scheduling of workbench-processing equipment. Arrange the already prepared workbench to the processing equipment.

The list algorithm based on the task-resource model is used to arrange the workbench on the processing equipment. Getting specific task-resources out can make tasks correspond to the clamped workbench, and resources correspond to processing equipment. So that we can get the sequence of task processing on each workbench, the beginning time and the end time of the processing. The initial state of the task includes the total time when parts on the table are all clamped. So the starting time of the processing should not be shorter than the total time of clamping. The processing of single equipment is a serial processing, and the processing of multiple devices is a typical parallel processing, as shown in figure 7.

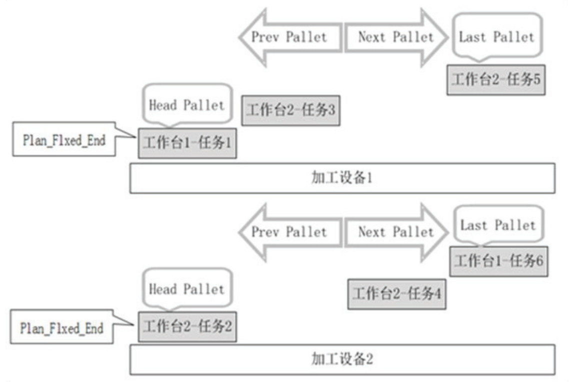

Fig.7 Multi-device parallel processing

(3) Removing: Schedule of workbench-removing device, the workbench is about to be arranged on the removed device.

The list algorithm based on the task-resource model is used to arrange the workbench on the removing equipment. Getting specific task-resources out can make tasks correspond to the workbench loaded with processed parts, resources correspond to the dismantling device. So that we can get the sequence of task removing on each table, the starting and ending time of removing. The initial state of the task includes the completion time of parts processing on the work table. So the start time of the disassembly parts should not be shorter than the completion time of processing. The removing of single equipment is a serial processing, and the removing of multiple devices is a typical parallel processing, as shown in figure 8:

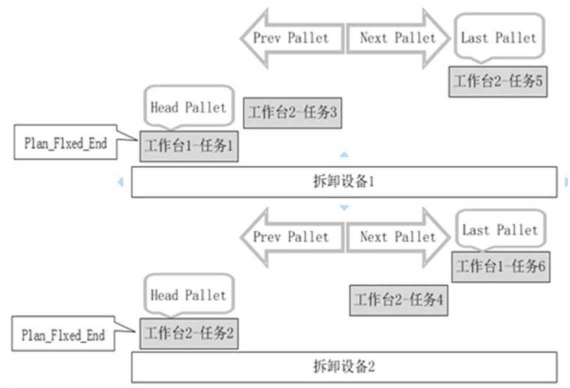

Fig.8 Multi-device parallel dismantling

4. System Development and Experiment

The scheduling experiments were done through the planning scheduling system which was developed independently to face flexible manufacturing system. The overall layout of the system is divided into six regions: the task area, control area, the parts clamping area, processing equipment area, logistics area, removing equipment area respectively. The parts clamping area, processing equipment area, demolition equipment area can be flexibly configurated, in order to accommodate the general flexible manufacturing system structure. Such as:

Flexible Manufacturing Systems "6-3-1" includes six workbenches, three devices, and one demolition equipment. Flexible manufacturing system "6-3-1" carry out the 13 tasks scheduling of multiple level programs, which is shown below. The red part of Figure 9 indicates the time for the part clamping, green part indicates processing time, the purple part indicates the time of removal. The same task start processing after clamping, and removing after complete processing. There is no conflict between the working sequence of the same task. Different tasks in the same table does not conflicted during the clamping process. The processing of different tasks on the same equipment does not conflicted. and the disassembly of different tasks on the same equipment does not conflicted either. The multi-level scheduling of flexible manufacturing system is realized here.

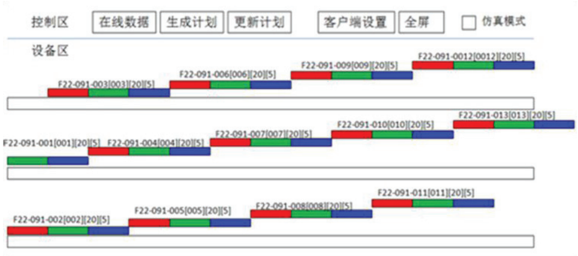

Fig.9 FMS 6-3-1 multistage plan

In flexible Manufacturing Systems "6-3-1", multi-task execute parallelly, as shown in Figure 10:

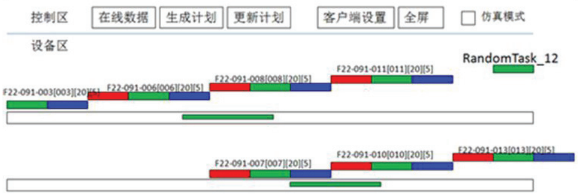

Fig.10 FMS 6-3-1 multitasking parallel execution

5. Conclusion

In this paper, a multi-level scheduling model of flexible manufacturing system is established, and the list algorithm is used to extend the model. A general flexible production scheduling algorithm is proposed, and a scheduling system based on the proposed algorithm is developed, which can realize the automatic scheduling of flexible manufacturing system. In the scheduling system, two kinds of system structure are used to carry out the experiment, which verifies the correctness of the model and algorithm, lays a foundation for further research on the scheduling and simulation of flexible manufacturing system.

References

[1] ZHANG Jianjun ,ZHANG Shaojing ,ZHANG Li. Modeling the Dynamic Scheduling System for FMS Based on Petri net[A]. Modern manufacturing technology and equipment; 2007(2).

[2] Zhang Xiaodong, Yan Hongsen. Integrated optimization of production planning and scheduling for multi-stage workshop [A]. Chinese journal of mechanical engineering; 2005, 41(9).

[3] WEI Jun-hu, GUAN Xiao-hong, SUN Guo-ji .Optimization methodology in simulation-based scheduling for semiconductor manufacturing [B]. Information and control;2000,29(5).

[4] WANG Shi-jin ,ZHOU Bing-hai ,XI Li-feng . A Filtered-Beam-Search Based Approach for FMS Dynamic Scheduling[A]. Journal of shanghai jiaotong university; 2007,41(1).

[5] ZHAO Jian-feng ,ZHU Xiao-chun,WANG Mu-lan ,BIAN Lei . Optimization and simulation of production scheduling of flexible manufacturing system based on genetic algorithm[A]. Manufacturing automation;2010, 32(5).

[6] Cao Yong-ning , Jiao Ai-sheng ,Zhang Min . The research of mixed genetic algorithm on workload assignment in FMS[A]. Mechanical research & application;2009, (1).