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Research on Optimization Method of Real-time Available Resources for Dynamic Scheduling

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Abstract

Aimed at the real-time request of dynamic scheduling to product resource, an optimization method of parallel dynamic chain real-time available resources was put forward. Proceed from real-time tracing of resource information influencing scheduling task's dynamic property, established a resource information's real-time tracing back and optimization model, which used module and parallel process mechanism to different kinds of real-time traced back resource information. The mechanism processed global dynamic feedback tracing for every module and optimized available resources primarily, on this basis, graded the primary available resources and gave a real-time candidate resource set. Through one example of one gear production scheduling, the method's validity was tested.

Keywords: *dynamic scheduling, real-time tracing, module and parallel process, available resources*

1. Introduction

Under the requirement of market, modern manufacturing are facing more and more competition. The advanced production management is an important competitive means, and production scheduling which plays a crucial role to improve production efficiency is the core and key of production management [1-2]. Classical scheduling theory simplifies the practical scheduling problems greatly [3], which hypothesis available resources infinite, task and processing time determined. However, most problems are uncertain in the actual production, such as the random task arrival, sudden fault of machines, etc, which could make the scheduling can't execute normally, and need to arrange again. Therefore, the enterprise how to work out a dynamic scheduling program scientifically, accurately, timely , according to their own actual production condition, is one of the key problems that modern manufacturing need to solve urgently.

Therefore researchers turn attention to dynamic scheduling problems that reflect practical production situation[4-7], and do a lot of researches on scheduling schemes and algorithms, but doesn't give explicit research method for real-time resources which reflect scheduling decision' real-time performance. These researches focus on requirement, track and analyze the existing resources when scheduling tasks happen. The advantage of this method is applied to the routine habit, and can deal with some of the common emergency effect remarkably. But, in the actual, production uncertain events occur frequently, scheduling arrangement should be changed in time, so this method which events happen taking measures will affect scheduling arrangement's performance, reduce the production efficiency, and, in the end, influence enterprise's rapid development in fierce market. Therefore, to achieve the dynamic scheduling efficiency, preparation that knowing about real-time production status should be done before scheduling task. So enterprises should track and analyze production status in time.

In view of the concrete problems faced by enterprise in dynamic scheduling, this article

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presents a deep research on real-time tracking and analysis method of resources before the task scheduling happened, puts forward the modular parallel dynamic real-time tracking concept. According the existing problems of resources tracking, comes up with the level classification method of real-time resources optimization, raises an algorithm for this method, and achieves the resources available sets at last. Thus, when event occurs the enterprises may, according to their real-time production resources information, arrange the corresponding scheduling in time. This tracking analysis method of real-time available resources set before incident happened, can real time control of the enterprise production reality, respond to any dynamic scheduling task in time. This is an effective and feasible way to support the timeliness of dynamic scheduling.

2. The Real-Time Tracing of Manufacture Resouce Information

The production resources contain mechanical processing equipments (lathe, milling machine, grinder, planer, gear hobbing, gear shaving machine) and the corresponding materials of equipments. This part varies the resource into different modules according to the workshops, machine varieties. The same level module resources are tracked parallelly, so as to avoid the time delay which caused by lengthy information of serial tracking. This method is called modular parallel processing mechanism. Specific module partition is shown as Figure 1.

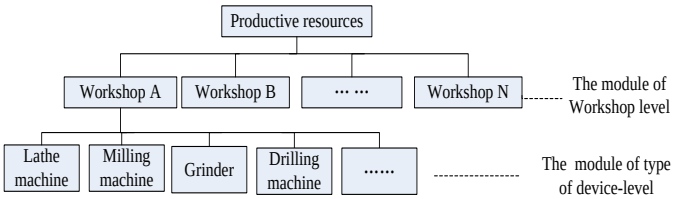

Figure 1. The Partition of Production Resources Module

Resource information real-time back applies computing programming and frequency division method summoned for the transfer of real-time information resources. According to enterprises' demands set the frequency band, by which tracing the state global resources steadily and updating the information of production resources real time. At last form a dynamic chain of production resources information. The state of real-time production resources information tracing is shown as Figure 2.

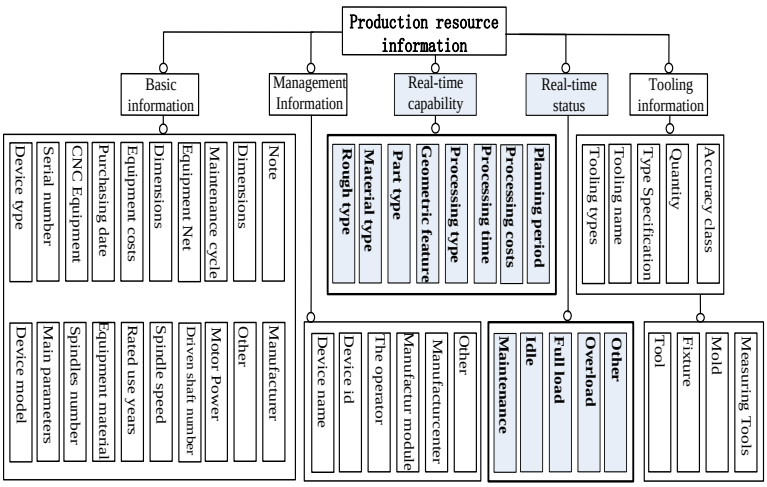

Figure 2. The Real-Time Tracing Information of Production Resources

The real-time state information of production resources in Figure 2 which is traced by frequency division method reacts actual situation of production directly, provides significant real-time data information for scheduling decision.

3. The Level Optimization Strategy of Real-Time Available Resources

Real-time available resources are those go through primary optimized arrangement and meet the demand of scheduling. The optimization mechanism analyzes and saves resources information in all level modules according to demand, and resources are collected into the central primary real-time available resources set eventually, which can avoid the disadvantages of time extension that caused by serial calculation of mass data, and to ensure the information processing's timeliness.

In this paper, the arrangement for scheduling task is according to the actual situation of production resources. Because the optimized resources of primary real-time available resources set have precedence relationships, we do further scheduling level analysis between primary available resources. If the remaining processing time about the equipment in the running state of completion is shorter, the loss of equipment is smaller, the level of the allowable value ability is taller then the scheduling level of this equipment is greater. If the surplus processing time, ability to use the allowable value, equipment loss of primary available resources is the same, we can judge again according to the basic information of this equipment. The priority level of the equipment is higher if the equipment processing precision is higher grades, the spindle speed is faster. The higher priority level, the greater likelihood invoked, which we called real-time resources level classification strategy in this paper. We provide real-time scheduling level with available resources sets for the task scheduling by primary and further hierarchical optimization of the real-time and global resources. The real-time available resources optimization process is shown as Figure 3.

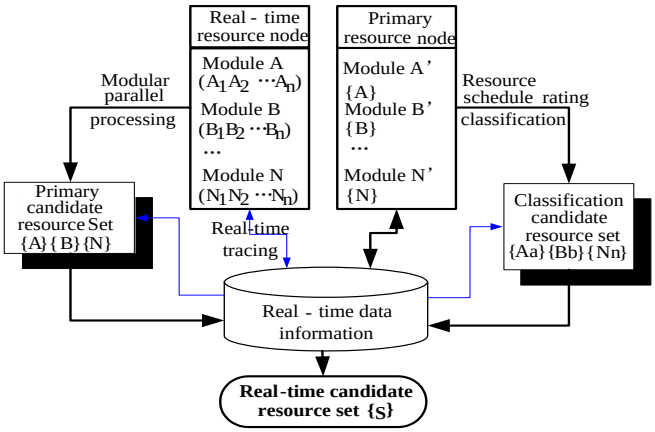

Figure 3. The Optimization Process Diagram of Real-Time Available Resources

4. Establishment of the Resources Optimization Model

What this article discussed is considering the arrangements of schedule tasks in accordance with the actual situation of resource, so it needs to analyze real-time changeable production resource, and to find the better available resources for dynamic schedule. The problem of resource real-time retrospective optimization is abstractedly described as the following mathematical description, and the real-time retrospective optimization of available resources includes three aspect indicators. Considering the condition of processing time of production resource, to solve the minimum remaining

processing time, considering the reasonability of schedule arrangements, the usable ability range of production resource is the important problem needed to be considered in optimization analysis, considering to the actual situation, tracking analysis is also need to be done on the corresponding associated resource of the available devices.

In order to establish the real-time retrospective optimization model of resource information, first to define the following parameters and variables, as shown in Table 1.

Table 1. Symbol Explanation of Model

set	parameter
{T}time set	't' is the start time number of resource information real-time retrospection
{M}raw material set	'I' is the device number
{S}device set	'j' is the material number
{A}primary candidate resource set of module A	'T' is processing time of the being used resource
{B}primary candidate resource set of module B	'T_{it}' is the remaining processing time of device I at time t
{N} primary candidate resource set of module N	'T_i^u' is the upper limit of allows schedule time for device i
{Aa}classification candidate resource set of module A	'CA' is the usable ability of produce resource
{Bb}classification candidate resource set of module B	'CA_{it}' is the allows produce ability of device i at time t
{Nn}classification candidate resource set of module N	'CA_i^u' is the upper limit of processing ability for device i
{Ta}time set of module A	'CA_i^D' is the lower limit of processing ability for device i
{Ma}raw material set of module A	'X_{it}' is the raw material processing volume of every device
{Sa}device set of module A	'ζ_{ji}' is the scale factor of device i consumes material j
{Mb}raw material set of module B	'R_j^U' is the upper limit of total supply of raw material j
	'R_j^D' is the lower limit of total supply of raw material j

Required to give a real-time available resources optimization program, under the condition of ensuring dynamic schedule requirement change, to real-time analyze the available resources. The maximum remaining processing time of resource is the shortest, the value of maximum allows usable ability is the least, and the value of corresponding resource maximum consume is the least, which are the goals to establish available resources optimization objective function.

$$\min \quad F(t) = \max \left(T_{it}, 1 - CA_{it}, \xi_{ij} X_{it}\right) \tag{1}$$

And meet the following constraint.

The remaining processing time of device is in the range of schedule requirement time.

$$0 \le T_{it} \le T_i^u \tag{2}$$

$$T_{it} = T_{ie} - T_I(x) \tag{3}$$

The safe operation of device is in the range of processing ability constraint.

$$CA_i^D \le CA_{it} \le CA_i^U \tag{4}$$

These two constraints are the analysis on the device of each module, but the actual schedule needs to consider the corresponding resource of every device, in this article, the device resource retrospectively analyzed has been done the further analysis about its actual condition of the required material, that is the required material of device produce needs to meet supplying the constraint of upper and lower limit.

$$R_j^L \le \sum_{i=1}^{D} \sum_{i \in Ij} \xi_{ij} X_{it} \le R_j^U, \; j \in M \tag{5}$$

The specific algorithm of real-time resource rating classification is described as follows.

If $T_{it} \le T_i^U$ in module A, that is the remaining processing time of the module A's device i is less than or equal to the prescriptive time upper limit T_i^U at time t, then, T_i is

figured in primary available resources set{Ta} of this module, or not figured. What the sort output is the eventually rating real-time available resources set $\{T_i, T_{i+1}, \ldots T_n\}$ with the practical value (where, $T_n \leq T_{n-1} \leq \ldots T_{i+1} \leq T_i$).

Obviously, this parallel dynamic chain real-time resource candidate is a resource optional method, which can directly point out the schedule available resources before the incident occurs, provide an effective method for analyzing schedule available resources, and provide a simple real-time decision criterion for dynamic schedule.

5. Analysis of Examples

This study has been applied to a gear factory, the article takes a type of gearbox with five speed gear shaft processing task as example, the increasing task required to put them into production within 12 hours. This shaft will be completed through forging, rough lathing, finishing, gear hobbing, face grinding, honing machining processing, in this case, turning of shaft end external circular carefully is treated as validation of processes, all of the production equipment has also been real time tracking by using the method proposed in this paper, analysis results can be real time traced according to the events, to determine the most suitable scheduling resource for this axis.

According to the description of this article real-time available resources optimization, optimize the candidate equipment of five speed gear-- intermediate shaft end external circular finishing turning, the end face cylindrical process constraint information is formed. First of all, global retrospective plant in March 13, 2012, 9:00 to meet the resources of the process, as shown in Table 2.

Table 2. Tracking of all Lathes Real-Time Status Information in the Factory

Device number	Device model	Real-time status of equipment	Start time (TS)	Completion time (Te)	Associated resources
C10101	CA6140	Full load	2012-3-10-8:00	2012-3-13-12:00	Sufficient
C10201	CA6140	Full load	2012-3-10-8:00	2012-3-19-12:00	Sufficient
C10202	C7620	Full load	2012-3-13-8:00	2012-3-13-17:00	Sufficient
C10203	CA6140	Full load	2012-3-12-12:00	2012-3-19-17:00	Sufficient
C10501	NC-D40	Overload	2012-3-13-8:00	2012-3-13-16:00	Sufficient
C10502	NC-D40	Full load	2012-3-13-8:00	2012-3-13-17:00	Sufficient
C10503	NC-D40	Full load	2012-3-13-8:00	2012-3-14-17:00	Sufficient

Secondly, the evaluation index is real-time traced back and optimized according to available resources, the module above is analyzed that resources to satisfy the minimum remaining processing time constraints and the scope of the ability to use constraints of the productive resources, and analysis equipment Corresponding to the associated resource with state constraints. Because both device status and the associated resource are in the same state in this module, so we can only consider production resources of the remaining processing time T_{ik}. $T_{ik} = T_{ie} - T_i(s)$, the real-time resources for the initial optimized, the results are shown in Table 3.

Table 3. Five-speed gears-the Middle of Axis Primary Optimization Results of Real-Time Resource

Device number	Device model	The remaining completion time(Tit)	Real-time status Of equipment	Associated resources
C10101	CA6140	3hours	Full load	sufficient
C10202	C7620	8hours	Full load	sufficient
C10501	NC-D40	7hours	Over load	sufficient
C10502	NC-D40	8hours	Full load	—

Once again, Primary optimization of real-time resource line is graded in this process, primary available resources exist in the same resources of time remaining, therefore, the resource scheduling level is evaluated according to the basic parameters of the resource

itself, as shown in Table 4.

Table 4. Five-speed Gear-the Scale of the Intermediate Shaft Real-Time Available Resources

Rat-ing	Device number	Device model	Remaining com-pletion time(Tit)	Real-time status of equipment	Associated resources
1	C10101	CA6140	3hours	Full load	sufficient
2	C10501	NC-D40	7hours	Over load	sufficient
3	C10502	NC-D40	8hours	Full load	—
4	C10202	C7620	8hours	Full load	sufficient

We can visually see that the factory lathe candidate set of resources available, according to the information in the table, and analyze the axis machining process required for all resource information, the process of candidates for the necessary equipment resources level optimized results are shown in Table 5.

Table 5. Five-speed Gear-Optimization Results of Intermediate Shaft Available Resources Level when the Process is All Set

The module	Rat -ing	Device number	Device model	The remaining completion time(Tit)	Real-time Status of equipment	Associated resources
Lathing	1	C10101	CA6140	3hours	Full load	sufficient
	2	C10501	NC-D40	7hours	Over load	sufficient
	3	C10502	NC-D40	8hours	Full load	—
	4	C10202	C7620	8hours	Full load	sufficient
Hobbing	1	G10301	Y3150E	2.5hours	Full load	sufficient
	2	G10501	YB3120	3hours	—	sufficient
Milling	1	X10501	X62W	4hours	—	sufficient
Shaving	1	T10202	Y4232	5hours	Full load	sufficient
	2	T10501	YWA4232	4.5hours	Full load	sufficient
Grinding	1	M10101	M2110	8hours	—	—
	2	M10102	M120W	9hours	Full load	sufficient
	3	M10501	MD2115	8hours	Full load	sufficient

From Table 5, it is intuitive that the available resources information that is available to the intermediate shaft scheduling. In the article, the way of retroactive analysis of available resources before the events is applied in the actual scheduling after the five-speed gear of a transmission in a gear factory- intermediate shaft tasks, this makes the task scheduling timely decision-making in the process, and improve the efficiency of scheduling, at the same time, the effect is significant, thus it verifies the validity of the proposed method.

6. Conclusion

Real-time control extent of the production resources and the optimization results directly influence the efficiency of the dynamic scheduling. This paper puts forward a kind of real-time optimal method called parallel dynamic chain real-time available production resources. With the aid of computer programming, setting up a production resources real-time tracing model which has a detailed list of the model's information; According to the available resources optimization problem, puts forward the real-time resources modular parallel processing mechanism and the available resources level classification strategy, establishes the mathematical model and detailed process. The proposed method has been successfully applied in gearbox dynamic scheduling of one Gear Factory.

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References

[1] Z. Shaqing, C. Xindu, C. Qingxin and C. Xin, "The research summarized and discussed of production project scheduling under uncertain environment", Computer application and research, vol. 28, no. 3, **(2011)**, pp. 809-813.
[2] G. E. Vieira, J. W. Herrmann and E. Lin, "Rescheduling manufacturing systems: a framework of strategies, policies, and methods", Journal of Scheduling, vol. 6, no. 1, **(2003)**, pp. 39-62.
[3] S. Allet, "Handling flexibility in a generalized job shop with a fuzzy approach", European Journal of Operational Research, vol. 147, no. 2, **(2003)**, pp. 312-333.
[4] G. Qingqiang, L. Qiqiang, L. Ming and D. Ran, "An achieving method of dynamic scheduling in continuous process", Computer Engineering and Applications, vol. 46, no. 15, **(2010)**, pp. 198-200,238.
[5] L. Lin, G. Hanyu and X. Yugeng, "The dynamic workshop rolling rescheduling of arrival time unknown", Chinese Journal of Mechanical Engineering, vol. 44, no. 5, **(2008)**, pp. 48-50.
[6] Z. Guanghui, Z. Guohai, W. Rui, J. Pingyu and Z. Yingfeng, "A dynamic scheduling method of unit manufacturing task by using real time production's information", Journal of Xi'an Jiaotong University, vol. 43, no. 11, **(2009)**, pp. 56-60.
[7] W. Xiuli, "The research of flexible job-shop dynamic scheduling problem", Journal of System Simulation, vol. 20, no. 14, **(2008)**, pp. 3828-3832.