R&D of Production Decision System for Discrete Manufacturing Industry

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Abstract. Based on the research background of the discrete manufacturing industry, the important role of production decision-making system is analyzed. Production decision method of the order demand analysis, production capacity and inventory reserves summary as a base for production scheduling is given, under the condition of limited stock and actual production capacity, production decision system in the application of the discrete manufacturing enterprises is implemented.

Introduction

At present, with the development of information technology and globalization, the discrete manufacturing industry is also in a rapid development stage. Discrete manufacturing enterprise with the characteristics of small batch and many varieties, asynchronous sheet production and high redundancy, etc.,¹ according to these characteristics, production scheduling for accuracy, reliability and real-time ability of workshop scheduling personnel at the production line should be highly required, at the same time, the enterprise needs to arrange the long-term production plan, and needs to focus on real-time warehouse reserves, equipment usage, etc., to complete the resource flows of production cycle and production schedule of product, etc. Solving these problems is increasingly dependent on core modules in ERP (Enterprise Resource Planning): production decision subsystem.

Production decision subsystem is one of the main modules of ERP, which makes use of the data transmission between each subsystem, optimizing operation and collaboration, the allocation of resources and production order among various subsystems. The production decision system can closely combine the various subsystems with departments of the enterprise, so that the enterprise can achieve the target of low inventory, high efficiency and low cost.² Therefore, real-time, accurate and efficient production decision-making system is of great significance to the production and operation of discrete manufacturing enterprises.

Design of Production Decision System Function Module

The production decision system developed by us is a subsystem of the developed ERP system, which realizes the complete integration with ERP system data. Decision system makes analysis and production scheduling of customer orders accepted by orders management module, to produce the final production plan, and put the production plan into the production module, guide the specific production in the workshop, to ensure that the enterprise’s normal and efficient operation. The basic business process is shown in Figure 1.
Figure 1. Production decision module business processes.

The production decision system is mainly divided into four functional modules, as shown in Table 1.

Table 1. Production decision system function module.

<table>
<thead>
<tr>
<th>The name of the module</th>
<th>Functional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up the time range of scheduling</td>
<td>Manually set up the time range of scheduling, according to the ability of the area to collect equipment and determine the time range of production.</td>
</tr>
<tr>
<td>Select the waiting list</td>
<td>The product that needs to be scheduled is obtained from the analysis result.</td>
</tr>
<tr>
<td>Automatic production scheduling</td>
<td>According to the equipment production capacity, warehouse stock to carry out production, get the temporary production plan.</td>
</tr>
<tr>
<td>Adjustment of scheduling results</td>
<td>If the obtained scheduling result does not meet the actual production situation of the workshop, the result needs to be adjusted.</td>
</tr>
</tbody>
</table>

**Algorithm Flow**

In this paper, the production scheduling model is given under the condition of the actual production capacity and the actual inventory reserves. For making production decision, the production capacity and inventory reserves are needed to be summarized firstly, and then the production decisions can be made in the actual production ability and the limited inventory range of the enterprises.

**Production Capacity Collection**

The production capacity information of enterprises can be shown in Figure 2. Machinery and equipment in Enterprises can be defined as the virtual equipment and equipment, including equipment refers to the specific each machine in the workshop, virtual equipment shall be carried out virtual partition in accordance with the equipment class, that all equipment of the same type can be defined as virtual equipment [3].
When the production capacity is summarized, according to the equipment, equipment maintenance plan and working calendar, the use of each equipment in the production area is counted. Then the equipment is projected for the virtual equipment $E_k$, statistics of $E_k$ in date $d_j$ production capacity (working time) $PT_{E_kd_j}$, as well as statistics of total production capacity of $E_k$ within the scheduling area.

$$PT_{E_k} = \sum_{d_j \in (t_{\text{start}}, t_{\text{end}})} PT_{E_kd_j}$$  \hspace{1cm} (1)

In this production scheduling model, according to the overall production capacity $PT_{E_k}$ of the virtual equipment within scheduling areas, to determine whether the enterprises have the ability to produce this product, if have, need to continue to make specific arrangement of production according to daily virtual equipment production capacity $PT_{E_kd_j}$.

**Summary of Inventory Reserves**

To determine whether the inventory can meet the production requirements, first we need know what materials are needed to produce each product $P_i$, and the BOM and process of $P_i$ can be used to know the material information of the production $P_i$. Therefore, the first step is to do product composition analysis to ensure the technical feasibility of product production. according to the BOM and process information, technical requirements analysis mainly refers to the process and material requirements analysis of the product, including BOM contains information product ratio of materials, process contains the information of the production process of product, the results of the analysis are expanded with the structure of BOM and process plan, such as $P_i$ unfolds as shown in Figure 3, the circular nodes represent materials, square nodes represent process. When the enterprise is in actual production, according to the expansion structure of $P_i$, the leaf node is processed to the root node.
product $P_i$ etc., also contains name, specification, unit, quantity of material node of the product $P_i$ etc. The information is too complex to be detailed in Figure 3.

After obtaining the material information the product needed, we use depth-first search algorithm to summarize the warehouse stock. First, search the material node information \{ $M_{i1}, ..., M_{im}$ \} of the product $P_i$, $P_i = k_1 M_{i1} + ... + k_i M_{i} + ... + k_m M_{im}$. Then check the inventory information \{ $s_i M_{i1}, ..., s_i M_{i}, ..., s_i M_{im}$ \} of the product $P_i$ in turn, $s_i$ represents the inventory amount of material $M_{i}$. Collect the warehouse stock and specify the material source for the product. When the raw material does not meet the production requirement, timely purchase and guarantee the production of the enterprise on the basis of the actual inventory capacity.

**Production Decision-making Process**

Based on the actual production conditions, in specific implementation process of production decision making algorithm, we need to assign processing time of each product node, because the product processing sequence is from leaf node to root node, so we need to depth first search the analysis results of product $P_i$, and the processing time of each node is assigned in the back, modify the dosage of virtual devices at the same time and provide the actual production capacity for the decision of the next production. When setting processing time, use the following settings:

1) \( t_s, t_e \) : start time, end time;

2) \( t_{\text{now}}, t_{\text{end}} \) : the next working day of the current time, end time of the last step;

3) \( PT_{mi} \) : procurement cycle of material $m_i$;

4) \( PT_{si} \) : entrust recruitment cycle of process $s_i$;

5) \( PT_{pi} \) : entrust recruitment cycle of finished products of product $P_i$;

6) \( PT_{E_kn_i} \) : the processing cycle of the homemade node on the equipment $E_k$;

7) \( PT_{E_kd_j} \) : the available processing time of equipment $E_k$ at time $d_j$;

8) \( PT_{\text{min}} \) : the minimum working time is the threshold value set by the enterprise, indicating that the equipment can work at a full load on the day after the remaining working time of the equipment is less than that of \( PT_{\text{min}} \). When the processing time is sufficient, if \( PT_{E_kd_j} < PT_{\text{min}} \), the processing time of date $d_j$ can be ignored, but it cannot be ignored when the processing time is insufficient.

In the retrospective assignment process, according to the different node types of tree structure in the Figure 3, the implementation process of production decision algorithm based on actual production conditions:

loop: if \( (t_n) == 0 \) then

\[ t_e = t_s \quad \text{break}; \]

else

if \( (t_{s,t_j} \geq t_n) \) then

\[ t_e = t_s + 1 \quad \text{break}; \]

else

if \( (t_{s,t_j} > t_{\text{min}}) \) then

\[ t_n = t_n - t_{s,t_j}; \]

\[ j = j + 1 \quad \text{goto loop}; \]

else

if \( ((T - t_{s,t_j}) < t_n) \) then
When the production decision algorithm is implemented, it needs depth-first search product analysis result. When searching for leaf nodes, it starts to go back to the traversal. Back in the assignment, we first need to determine product node types, including nodes of materials, entrust recruitment of process, entrust recruitment of finished products and homemade work node, and then according to the different node types, start time and end time of nodes can be specifically assigned.

Conclusions

Combined with the characteristics of discrete manufacturing industry, this paper puts forward a more practical scheduling model, and has successfully applied this model to production decision system. The production decision system based on improved production scheduling model is divided into three phases of production capacity summary, inventory reserves summary and scheduling, the production decision based on limited inventory and limited production capacity has been achieved. The start and end time and the source of processing materials of each production process of customer orders can be set within the scheduling areas, to ensure the validity and rationality of production decisions in discrete manufacturing enterprises, so as to improve the competitiveness of discrete manufacturing enterprises.

References


