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Crossover material prediction and simulation for supply-demand balance in the production logistic system

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ABSTRACT

Focus on the complex logistic structure of modern hybrid process work shop, the optimization inventory model is set up with the objective is not only to meet the content limit, but also to minimize the warehousing costs and ensure the supply-demand balance of each machine unit. On this basis, the application software system for inventory prediction and simulation is developed and the effectiveness of the system is illustrated at last.

KEYWORDS

Material prediction;
Material simulation;
Supply-demand balance;
Production logistic system.

INTRODUCTION

In the modern hybrid process work shop, there are many kinds of materials and complex physical flow structure among the storehouses of raw material, WIP and finished productions. When the dynamic events from product lines come into being, such as machine breakdown, urgent order, process parameters change and etc., it becomes extremely difficult to optimize the production planning and scheduling, especially for the long term lot contract, to realize just in time and lean production. Therefore, how to predict and simulation the real-time logistic condition during the planning period in the production line plays an important role in supporting the integration of multi operation production planning and realizing the global optimization.

So far, the topic of material prediction and simulation has been attracts the attention of academic circles and the research result can be searched. As for the enterprise external supply chain, a fundamental yet practical approach to tactical inventory management problem is presented in[1] and a simulation-based optimization framework for inventory management in supply chains under uncertainty conditions is presented. As for the enterprise internal sale inventory, the radial basis function network (RBFN) is presented for irregular demand time series and the effectiveness of RBFN is demonstrated by simulation experiment in[3]. However, for the different kinds of material in the complicated production system, including raw material, WIP and finished productions, especially for the inventory change during the planning period, the research result cannot be searched. In the paper, by thoroughly analysis of the production logistic structure, the inventory optimization model is set up. On this basis the real-time prediction and simulation system is developed.

PROBLEM ANALYSIS

The typical hybrid process work shop with complex structure can be illustrated as Figure 1. In the production system, there are five kinds of finished products stored in FP (1) to FP (5) and eleven machined units identified as MU (A) to MU (I). There are six WIP storehouses with limited content between upstream operation and downstream operation. The supply-demand relationships are identified as arrows that are the material flow routes. The aim of the system is to decrease inventory level under the premise of guarantee the continuous of processing.

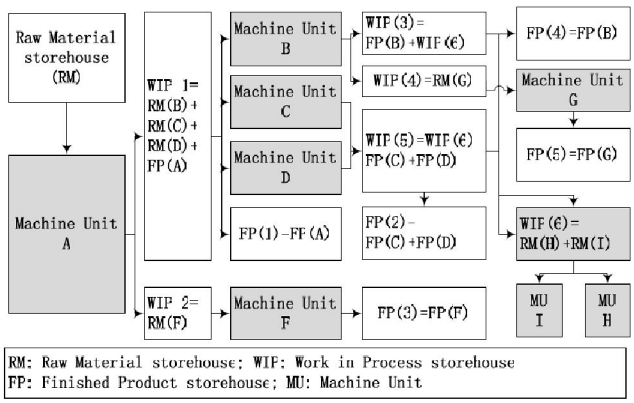

Figure 1 : The production line condition

OPTIMIZATION MODEL SETUP

In order to convenient, introduce the following signs:

T: plan period;

j: serial number of WIP storehouses $j=1,\cdots,N$;

u: serial number of supply times to WIP storehouses, $u\in U_j$;

ts_{ju}: the time period of the th supply of th storehouse;

tc_{ju}: the intervel of th storehouse between th supply and (+1)th supply;

s_{ju}: the quantity of WIP in th storehouse before th supply;

s'_{ju}: the maxmum quantity of WIP in th storehouse after th supply;

U_j: the set of th storehouse supply times in plan period;

SH_j: the upper limit of th storehouse;

SL_j: the lower limit of th storehouse;

v_j: the external demand of th storehouse;

v_0: production rate;

H_j: the storage cost of th storehouse per time unit;

On the problem analysis mentioned above, the optimization model is sepup as follow:

$$Min\sum_{j=1}^{N}\sum_{u\in U_j}[(s_{ju}+s'_{ju})\times ts_{ju}+(s'_{ju}+s_{j,u+1})\times tc_{ju}]\times H_j/2 \quad (1)$$

s.t.

$$s_{j,u+1}=s_{ju}+ts_{ju}\times(v_0-v_j)-tc_{ju}\times v_j\ge SL_j,\forall j=1,...,N,u\in U_j \quad (2)$$

$$s'_{ju}=s_{ju}+ts_{ju}\times(v_0-v_j)\le SH_j,\forall j=1,...,N,u\in U_j \quad (3)$$

$$ts_{ju}\ge 0,tc_{ju}\ge 0,\forall j=1,\dots,N,u\in U_j \quad (4)$$

$$s_{ju},s'_{ju},ts_{ju},tc_{ju}\in Z \quad (5)$$

$$T=\sum_{u\in U_j}(ts_{ju}+tc_{ju}),\forall j=1,\cdots,N \quad (6)$$

In the model, the equation (1) represents that objective function consists of inventory cost. The formula (2) represents the balance of quantity of WIP. The equation (3) represents the maximum of WIP in storehouses meets with the content limit. The formula (4) represents the minimum switching time period and supply interval is non-negative. The formula (5) represents the all variables data type are integer. The formula (5) represents the machine units cannot be idle. Deb et al. put forward the NSGA II algorithm, and is one of the most effective evolutionary algorithm by far[4], this paper adopts the NSGA II algorithm to solve the above example, crossover probability P_c=0.7; Mutation probability P_c=0.1

SOFTWARE SYSTEM IMPLEMENTATION

Database design

SqlSever 2000 is adoped in the programe realization and there are totally thirteen tables defined in the database, as shown in TABLE 1.

Interface design

C# is adoped in the system development. The main interface is illustrated as shown in Figure 2. There are six functions model in the system, including data receiving, parameter setup, start computing, requirement planning, inventory prediction and machine prediction. After clicking the function button named parameter setup,the interface can be seen and all kinds of production parameters are initialized here. Accoding to the assignment values, the production system structure is display by graph and the computing can begin.

TABLE 1 : Tables defined in the database

Table name	Description
In_base_machine	Table of machine units
In_base_stock	Table of storehouse
In_flow_definition	Table of material group
In_contract	Table of contract
In_flow_tech	Table of material group resovler
In_machine_stop_time	Table of time of machine units stop
In_product_plan	Table of product plan
In_resource_stock	Table of raw material storehouse
In_run_parameter	Table of running parameter
Out_demand_reference	Table of demand record
Out_machine_record	Table of production record of machine units
Out_stock_record	Table of inventory record

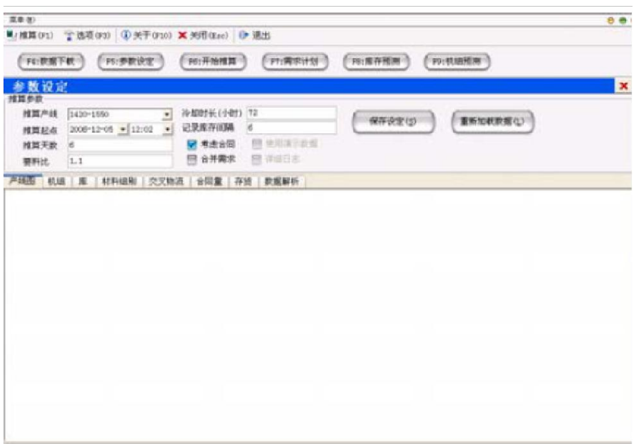

Figure 2 : The main interface

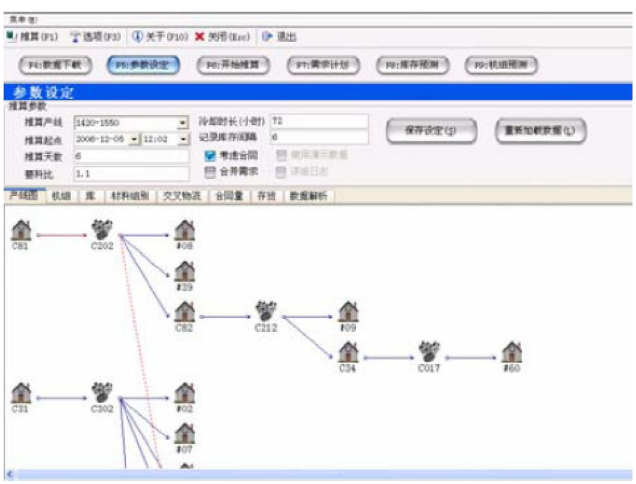

Figure 3 : The production system structure

Application effect

The running effect of the prediction and simulation system developed in the paper can be illustrated as shown in Figure 4-Figure 7

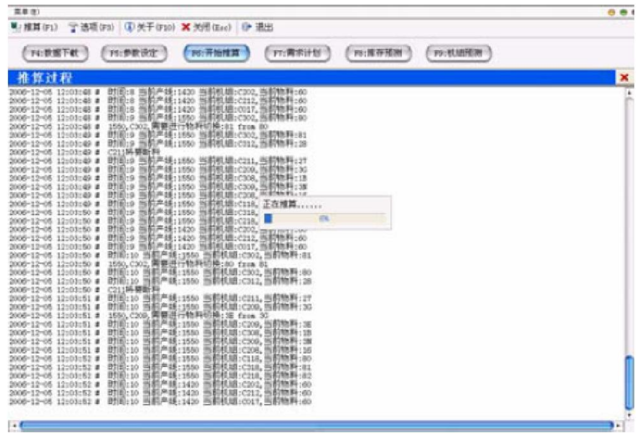

Figure 4 : The computing process

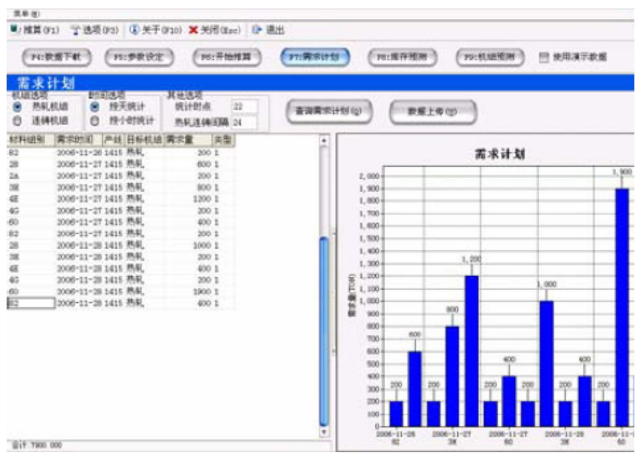

Figure 5 : The requirement plan

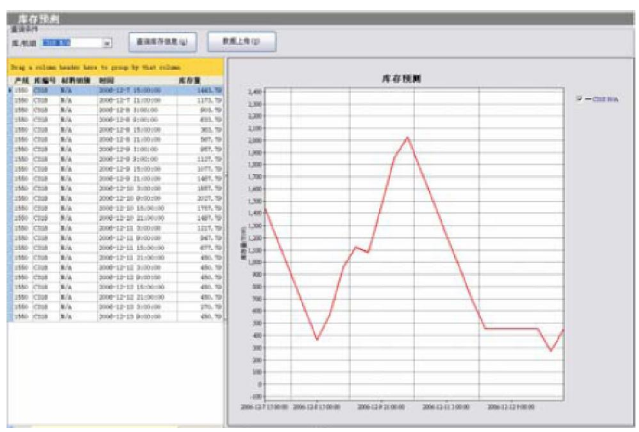

Figure 6: The material prediction and simulation

Computing process and result are displayed, as shown in Figure 4. On the interface, the real-time logistic condition of each machine unit can be seen.

According to the computing results, the requirement time and requirement quantity of each material group are displayed, as shown in Figure 5.

The inventory condition and changing trend of each material stored in the warehouse are displayed, as shown in Figure 6. For the abnormal condition, for example, exceeding content limit or machine stop for material, warning will be given. The Statistical inventory condition and changing trend of all material stored in the warehouse are displayed, as shown in figure 7

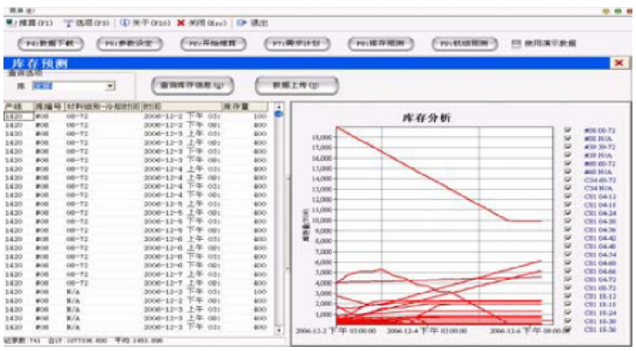

Figure 7 : Whole inventory prediction and simulation

SUMMARY AND PROSPECT

In this article, considering the complicated production logistic structure of modern industry, the application software system for crossover material prediction and simulation is developed. In the system, the optimization inventory model for the supply-demand balance is setup. On this basis, by systematic simulation the process condition of each kind of material, the material requirement in the planning period can be predicted. The Solving algorithm adopted in the paper is a kind of general algorithm. In the next work, new solving procedure will be designed and algorithm will be realization with considering the specific characteristics of problem.

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