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Design and implementation of production logistic prediction software system

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ABSTRACT

Focus on the information management in the modern chemical industry, the production logistic prediction model is set up with the objective is not only to minimize the warehousing costs, but also to reduce the machine switching time. On the base of the core model, the prediction software system of production logistic is designed and developed. At last, the implementation effectiveness is illustrated.

Key words: information management, production system, logistic prediction.

INTRODUCTION

In the modern chemical and pharmaceutical enterprises, management informatization has become the focus of academic research and application practice. There has been many research results obtained, such as ERP, OA, MES and etc , which make the working efficiency get improved[1].Meanwhile, as for working site management, especially for the increasingly complex logistic optimization, there rarely been realized by software system. The design idea of logistic information system for chemical and pharmaceutical enterprises is discussed in [2]. On the logistic prediction, the bottleneck closed loop method based on bottleneck polymorphism is proposed in [3]. In the paper, by deeply analysis of the process flow in the production line, the optimization model of logistic prediction is setup. On this basis, the application software system is implemented, by which the real time machine unit prediction and inventory prediction can be realized.

PROCESS FLOW ANALYSIS

With the data of domestic chemical enterprises, the typical hybrid process flow in the work shop can be illustrated as Fig. 1. In the system, there are five machine units, one raw material storehouse and two WIP storehouses with limited content. MU A has three process switching modes which provide three kinds of production respectively, which are FP(A), RM(B) and RM(C).The technical routes are identified as arrows, that are the material flow routes. The aim of the system is not only to minimize the warehousing costs, but also to reduce the time cost of machine process switching under the premise of guarantee the continuous of processing.

III. Logistics Prediction Model Setup

In order to convenient, introduce the following signs:

On the basis of process flow analysis mentioned above, the prediction model is setup as follow:

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

$s.t.$

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

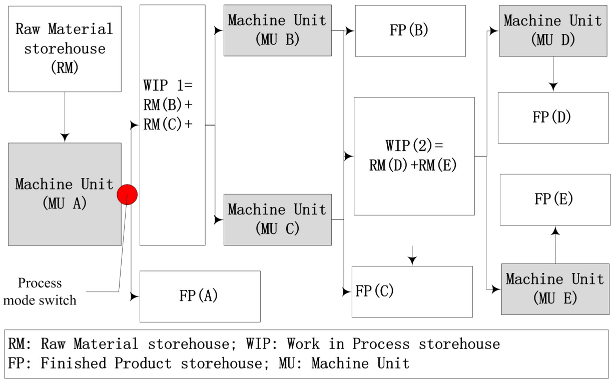


Figure 1. **Process flow**

T	Plan period
j	Serial number of WIP storehouses
u	Serial number of supply times to WIP storehouses
ts_{ju}	The time period of u th supply of j th storehouse
tc_{ju}	The interval of j th storehouse between u th supply and (u +1) th supply
s_{ju}	the quantity of WIP in j th storehouse before u th supply
s'_{ju}	The maximum quantity of WIP in j th storehouse after u th supply
U_j	The set of j th storehouse supply times in plan period
SH_j	The upper limit of j th storehouse
SL_j	The lower limit of j th storehouse
v_j	The external demand of j th storehouse
v_0	Production rate
B	The shortest switching time for machine unit
H_j	The storage cost of j th storehouse per time unit
C_j	The switching cost for supply j th storehouse

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

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

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

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

The objective function is to minimize the cost of warehousing and machine process switching, as formular (1). Formula (2) represents the quantity balance of WIP. Formula (3) represents the maximum of WIP in storehouses must meet with the content limit. Formula (4) represents the minimum switching time period and supply interval is non-negative. Equation (5) represents the all variables data type are integer. The Equation (6) 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 $P_m = 0.1$.

IV. SOFTWARE DESIGN

A. Database Design

SqlSever 2000 is adopted and there are totally eighteen classes defined in the database, as shown in table 1.

TABLE I. CLASS DEFINITION IN THE PROGRAM

Class Name	Description
Machine	Machine units class
Stock	Storehouse class
MachineItem	Material group class for specific machine unit
StockItem	Material group class for specific stock
FlowTree	Process flow tree class
CrossFlow	Crossover logistic class
Calculator	Computing class
FlowForest	Process flow tree class: trees identify the relationship between operations
StockTrace	Tracker that record the stock variation
FlowParser	Class of the material group string analytic
ShiftAlgorithm	Switch algorithm class that must be inherited by specific algorithm
DBUtil	Database communication class
ItemAppraise	Class for evaluate the process condition of specific material on machine unit
DataType	Self-definition date type class
CommUtil	Common used object class
ShiftCause	Recorder class of switch cause
AppraiseLog	Tracker class of switch process
Log	Log class

B. Software Function Design

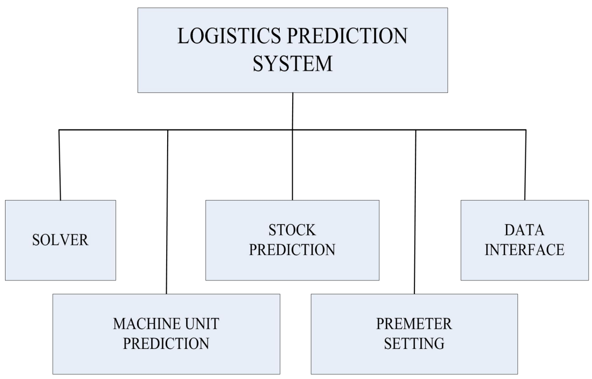
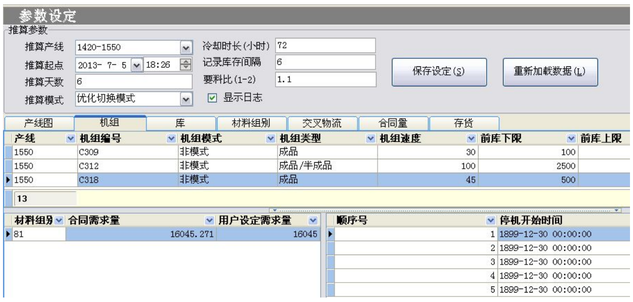


Figure 2 The system function

C# is adoped in the system development. There are five functions modules in the logistics prediction system, including data interface, parameter setting, stock prediction, machine unit prediction and solver, as shown in Fig.2.



产线	机组编号	机组模式	机组类型	机组速度	前库下限	前库上限
1550	C309	非模式	成品	30	100	
1550	C312	非模式	成品/半成品	100	2500	
1550	C318	非模式	成品	45	500	

材料组别	合同需求量	用户设定需求量
81	16045.271	16045

顺序号	停机开始时间
1	1899-12-30 00:00:00
2	1899-12-30 00:00:00
3	1899-12-30 00:00:00
4	1899-12-30 00:00:00
5	1899-12-30 00:00:00

Figure 3 Machine units setting

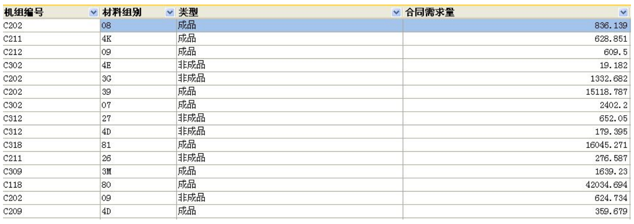
Figure 3- Figure 5 illustrate how to set parameters according to specific production line, including machine units setting, stock setting, material group setting and requirement quantity setting.

产线	库编号	库存下限(目标)	库存上限	库类	材料组别
1550	C31	25000	30000	原料库	81
1550	C32	10000	15000	中间库	05
1420	C34	2300	4000	中间库	81
1550	C57	4500	8000	中间库	82
1420	C81	15000	20000	原料库	82
1420	C82	3000	6000	中间库	28
1550	C85	6000	8000	中间库	05
1550	D01	2000	3500	中间库	81
1550	D02	2000	3500	中间库	81

Figure. 4 The stock setting

产线	材料组别	类型	工艺路径
1550	02	主体物流	stockC31[0]-machineC302[2,220]-stock#02[0]
1420	04	内部交叉	stockC81[1227.8]-machineC202[2,150]-stockC32[229.28]-machineC312[0,100]-stc
1550	05	主体物流	stockC31[5565.1]-machineC302[2,220]-stockC32[3586.49]-machineC312[0,100]-st
1550	07	主体物流	stockC31[64.51]-machineC302[2,220]-stock#07[0]
1420	08	主体物流	stockC81[24.11]-machineC202[2,150]-stock#08[0]
1420	09	主体物流	stockC81[15.95]-machineC202[4,100]-stockC82[0]-machineC212[0,60]-stock#09[(
1550	16	交叉物流	stockC32[7111.77]-machineC208[0,40]-stock#16[0]
1420	18	内部交叉	stockC81[0]-machineC202[2,150]-stockC32[0]-machineC208[0,40]-stock#18[0]
1550	19	主体物流	stockC31[3477.84]-machineC302[2,220]-stockC32[2356.69]-machineC208[0,40]-st
1420	1A	内部交叉	stockC81[615.62]-machineC202[2,150]-stockC32[846.06]-machineC308[0,36]-stoc
1550	1B	主体物流	stockC31[90]-machineC302[2,220]-stockC32[540.5]-machineC308[0,36]-stock#1B|
1550	25	交叉物流	stockC57[3136.61]-machineC211[0,28]-stock#25[0]
1550	26	交叉物流	stockC32[0]-machineC208[0,40]-stock#26[0]

Figure.4 The material group setting



机组编号	材料组别	类型	合同需求量
C202	08	成品	836.139
C211	4K	成品	628.851
C212	09	成品	609.5
C302	4E	非成品	19.182
C202	3G	非成品	1332.682
C202	39	成品	15118.787
C302	07	成品	2402.2
C312	27	非成品	652.05
C312	4D	非成品	179.395
C318	81	成品	16045.271
C211	26	非成品	276.587
C309	3M	成品	1639.23
C118	80	成品	42034.694
C202	09	非成品	624.734
C209	4D	成品	359.679

Figure.5 The requirement quantity setting

C. Application Effect

The running effect of the prediction system developed in the paper can be illustrated as shown in Fig.6 -Fig.7

As shown in Fig.6, on the interface, the real-time stock condition and changing trend of specific material stored in the warehouse can be seen. Once the urgent events occur, for example content limit exceeded, warning will be given. As shown in Fig.7, on the interface, the real-time machine condition and changing trend of specific material processed on the machine unit can be seen. Once the urgent events occur, such as machine stopped waiting for raw material, warning will be given.

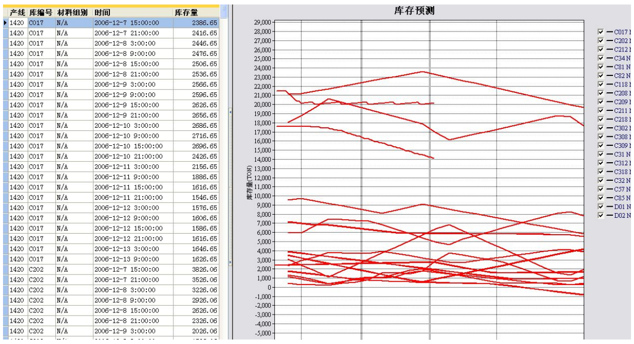


Figure.6 Inventory prediction

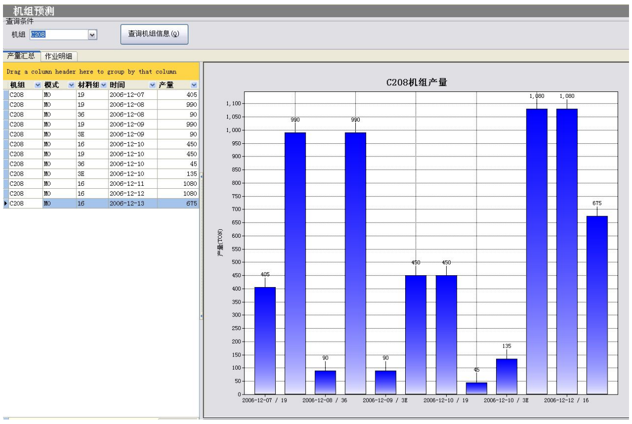


Figure.7 Machine unit prediction

CONCLUSION

As one of the new hot points discussed in the modern chemical industry information management, the real-time prediction of production logistics is concerned in the paper. Through study the process flow on the production line, the logistics prediction model is setup, which aims at not only decreasing the cost of process switching and material warehouse but also meeting with machine requirements and content limits. With the model embedded, the application software system is designed and realized. By real-time monitoring and predicting, the condition of raw material, work in process and finished product can be illustrated on the interface and this can well help to improve operation efficiency and economic benefits.

In the paper, 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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