Research on the Model of Iron and Steel Enterprises Group Production Scheduling Orienting to Group Enterprises Management Pattern

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Abstract—**In order to satisfy the demand of iron & steel enterprises on group-oriented management pattern and resolve the difficulties in the whole management, control and scheduling on every stock company, a linear 0-1 programming model orienting to group enterprises management pattern is proposed by analyzing the characteristics of iron & steel group enterprises management pattern. The objective is to maximize the profit of iron and steel enterprises group. In the model, the constraints of equipments capabilities and resources configuration in each corporation are considered enough. The optimal group scheduling result of the market orders can be obtained by solving the 0-1 programming model. Finally, the application case of the model is represented, and the results show that the algorithm model is valid and feasible for practical application.**

Keywords—**iron and steel enterprise, group-oriented management pattern, group scheduling, profit maximization**

I. INTRODUCTION

Enterprises group is the advanced form of business organization. It is a large-scale and multi-level enterprises union consisting of several independent business entities in the methods of combination, recombination and mergence etc. Its purpose is to realize the reasonable division and collaboration by optimizing the elements of production and operation, to achieve the advantage emphasis and complementation, to reduce the operational cost, and then realize the profit maximization of enterprises.

In the current age of business globalization and worldwide marketing, enterprises are forced to compete against considerable competitors from all over the world. A tendency, recently, which enterprises incorporate into enterprises group in order to enhance the competition ability is occurred in the iron & steel industry of China. Sequentially, after enterprises group is established, many problems emerge. Those include how to manage the enterprises located in different regions, how to reengineer the business process and optimize global resources configuration, and how to deal with the relationships between group and each affiliated corporation which is a joint stock company that has independent financial statement. How to resolve the problems mentioned above has become the key problem for enhance the whole competition ability.

To study the group scheduling problem, we are inspired by research works in the fields of order allocation in supply chain and production planning of multi-plants enterprise because of the similarities of both problems. In article [1], a stochastic programming based approach is described to model the planning process as the demand is uncertain in supply chain. The objective is to minimize the cost. Articles [2][3] study the production distribution and transfer in a multi-plant, multi-term, multi-period, capacitated environment, and presents a Lagrangean-based approach. Reference [4] deals with a capacitated master production planning and capacity allocation problem for a multi-plant manufacturing system with two serial stages in each plant. Article [5] proposes an integrated process planning and scheduling model for the multi-plant supply chain. The objective of the model is to decide the schedules for minimizing total tardiness through analysis of the alternative machine selection and the operation sequences in the multi-plant supply chain. A mixed integer linear programming model for orders dispatching in a supply chain with multi-product, multi-order, and multi-period is proposed in [6]. The objective is to minimize the total sum of production cost, transportation cost, and earliness and tardiness penalties of entire manufacturing and distribution network. Y. Yang [7] develops an objective function on minimizing total cost and response time. J.H. Zhou and D.W. Wang [8-11] study the production planning model and arithmetic for multi-location plants.

The rest of the paper is organized as follows. Section 2 analyzes the characteristics of group-oriented management pattern. Section 3 describes the practical requirement of group scheduling. Then, a group production scheduling model for iron and steel enterprise is presented in section 4. Section 5

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represents the practical application case of the model. Finally, section 6 concludes this paper.

II. GROUP-ORIENTED MANAGEMENT PATTERN

In the enterprises group, the organization of whole group is divided into two levels: the group decision management level and the corporation management level. The group (decision management level) globally manages the sales, purchasing, finance and resources, etc so as to avoid the competition among corporations and strengthen the influence on the market for the maximum benefit. The corporations which are affiliated to the enterprises group must obey the scheduling demands from the group decision management level. And they also have the autonomous rights to manage production, inventory, material supplying and product delivery, etc because it is a public stock company and has independent financial statement. Yet, the corporations have no rights to sale and purchase.

The order process under advanced group-oriented management pattern is introduced. Take a customer order, for example. Typically, if customer wants to order steel product, the order must be sent to the group contract department, and then the scheduling room of contract department schedules the contract by balancing the production abilities of all corporations and then sends the scheduling contract to the corresponding corporation. Then the product logistics business begins after the task of production is finished.

III. PROBLEM DEFINITION

We consider the problem of group production scheduling and capacity allocation for an iron and steel enterprises group composed by group headquarters D and J member corporations located in different regions. The enterprises group seeks the maximization of whole enterprises group's total profits under the conditions of limited resources (order resources, equipment capacity, etc). MTO (Make-To-Order) is adopted by the enterprises group to organize production. All the affiliated corporations have the capacities to produce the different products in the similar type. It is assumed that the production is continuous production. It means the manufacturing procedure from starting to finishing without any interruption according to the manufacturing sequence, i.e. the complete manufacture procedure must not be interrupted.

Since the same type of product produced in different member corporations (production base) and according to the different routings, the production cost and demand for resources are different. Therefore, the purpose for production schedule is to choose the reasonable routings to distribute the orders to the member companies to realize the profit maximization under the condition of resources limitation. Due to this rough production schedule focus on production base, therefore, the procedure in the routings will be accurated to the branch factory of the member corporations (production base) (so-called production-base-level routings). As for the equipment resources, the production capacity in critical operated center of production base will be considered, instead of concreted procedure and equipment in each workshop of enterprise.

IV. MODEL DEVELOPMENT

The group has J member corporations. It has received L orders during schedule period [1, T]. The types of product need to be manufactured are I. The demand amount of order l (l = 1 ～L) per product i (i = 1～I) is $w_{il,}$ and the required delivery time is t_{il} (time period will be seen as one unit).

Product i is priced at p_i by enterprises group. The price here is factory price according to pricing model of iron and steel enterprises group. That is, it is the price of the customer taking goods from the plant. For the various fees arised by delivery to destination should be borne by customers themselves.

It is assumed that there are K_j production-base-level routings in member corporation j (j = 1～J). Since the same type of product produced in different member corporations (production base) and according to the different routings, the production cost and demand for resources are different. Therefore we set the production cost c_{ijk} for product i which is produced in member corporation j according to routing k (k = 1 ～K_j). The occupied coefficient for critical operated center m is h_{ijm} that the member enterprise j produces the product i. $H_{jm}(t)$ is available capacity of critical operated center m of member enterprise j in period t.

Due to the incompletely matches between the demand from customer and capacity of enterprises, the enterprise will not delivery the goods in time according to requirement of customer. The advanced producing will overspend active capital, stock, and increase inventory costs. The delay of delivery will pay tardiness penalty to customer, meanwhile reduce the customer satisfaction of the company. Therefore, both of advance / delay delivery will arise the corresponding penalty payment to customer. Normally the earliness / tardiness penalties are in direct proportion to the value of order. It is supposed that the different products have different penalty factors, and the earliness and tardiness penalty factors for product i per unit time and unit price are α_i and β_i.

Decision variables

$$x_{lijk}(t) = \begin{cases} 1, & \text{if the product i of order l is produced in enterprise j} \\ & \text{according to technology k, and deliver it to customer} \\ & \text{at period of time t.} \\ 0, & \text{others} \end{cases}$$

Group scheduling model based on profit maximization of iron and steel enterprises group is as follows:

$$\max Z = \sum_{l=1}^{L}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K_j}\sum_{t=1}^{T} p_i w_{il} x_{lijk}(t)$$
$$-\sum_{l=1}^{L}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K_j}\sum_{t=1}^{T} c_{ijk} w_{il} x_{lijk}(t)$$
$$-\sum_{l=1}^{L}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K_j}\alpha_i p_i w_{il}\sum_{t=1}^{t_{il}-1}(t_{il}-t)x_{lijk}(t)$$
$$-\sum_{l=1}^{L}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K_j}\beta_i p_i w_{il}\sum_{t=t_{il}+1}^{T}(t-t_{il})x_{lijk}(t) \qquad (1)$$

s.t.

$$\sum_{j=1}^{J}\sum_{k=1}^{K_j}\sum_{t=1}^{T} x_{lijk}(t) = 1, \qquad \forall l, i; \qquad (2)$$

$$\sum_{l=1}^{L}\sum_{i=1}^{I}\sum_{t=1}^{N} h_{ijm}(t) w_{il} x_{lijk}(t) \le \sum_{t=1}^{N} H_{jm}(t),$$
$$\forall j, m, N = 1, 2, \ldots, T; \qquad (3)$$

$$x_{lijk}(t) = 0 \text{ or } 1, \qquad \forall l, i, j, k, t; \qquad (4)$$

The objective of the model is profit maximization of whole enterprises group. In formula (1) the first item represents saleroom within planned period; the second item means production cost; the third and fourth items are the earliness / tardiness penalties.

The constraint condition (2) means one type of product in any one order should be manufactured according to one routing of one member enterprise in a planned period; the constraint condition (3) means the production should meet the limitation of resource available.

V. MODEL SIMULATION

Branch and Bound algorithm can be used to obtain the optimal result due to a standard 0-1 linear programming model. Genetic Algorithm and Simulated Annealing Algorithm will be generally applied to this field recently.

The model and Branch and Bound algorithm are used to do the calculation on examples, and their results are satisfied. However, in this paper, the small- scale example will be given to demonstrate the approach of model.

This enterprise consists of two member companies which have the capacities to produce the product 1 and product 2. The factory price of product 1 is 5500, and the factory price of product 2 is 6300. Each company has two routing possibilities to follow, and one critical operated center. The relevant parameters of group and member companies refer to Table 1, 2. In the planned period [1, 4], there are totally 3 orders, the relevant parameters refer to the Table 3. Then put the relevant parameters into the model to calculate. The results refer to Table 4, and the target value is 168300. This result will do the help to make the unified production schedule which will be obeyed later to make production schedule, material procurement schedule and daily operated schedule.

TABLE I. PARAMETERS OF ENTERPRISES GROUP

Product i	**Factory Price p_i**	**Production Cost c_{ijk}**				**Earliness penalty factor**	**Tardiness penalty factor**	**occupied coefficient for critical operated center h_{ijm}**	
		Company1		***Company2***					
		Routing 1	**Routing 2**	**Routing 1**	**Routing2**			***Company 1***	***Company 2***
1	5500	4200	4000	4100	4300	0.15	0.35	10	12
2	6300	4500	4800	4700	4400	0.20	0.40	15	13

TABLE II. PARAMETERS OF ENTERPRISES GROUP

Available capacity of critical operated center $H_{jm}(t)$							
Company1				***Company2***			
Period of time 1	**Period of time 2**	**Period of time 3**	**Period of time 4**	**Period of time 1**	**Period of time 2**	**Period of time 3**	**Period of time 4**
62	65	60	63	55	72	68	70

TABLE III. PARAMETERS OF ORDERS

Order l	**Production Demand w_{il}**		**Delivery Time t_{il}**	
	Product 1	***Product 2***	***Product 1***	***Product 2***
1	5	6	2	3
2	6	8	1	2
3	7	5	3	2

TABLE IV. RESULTS OF MODEL

Order 1	Product i	Company1								Company2							
		t(k=1)				t(k=2)				t(k=1)				t(k=2)			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
l=1	i=1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	i=2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
l=2	i=1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	i=2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
l=3	i=1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	i=2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

VI. CONCLUSION

The study for enterprises group becomes the keen issue currently. However, the study for the model of iron and steel enterprises group production scheduling oriented to group management pattern is rare. This paper establishes the model against the characteristic of production and price to realize the profit maximization. In this model, the constraints of equipments capabilities and resources configuration in each corporation are considered enough. At the same time, the calculation on the example is done by Branch and Bound algorithm. The result of calculation demonstrates the validity of model.

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