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Combinatorial Optimization Model and Algorithm of Material Dispatching with Supply Priority

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Abstract: As for a company with continuous and mass production, such as T iron and steel company, its supply logistics of material has characteristics of high interspaces, multiple suppliers and complex transport scheme. It is of great significance to coordinate the trade-off between transport cost and inventory cost and thereby realize the lean supply for continuous production and cost control of the company. According to the difficulties to coordinate the supply rhythm and supply quantity when multiple suppliers provide the same material, we establish a material dispatching model and make a solving algorithm on the basis of continuous production and cost minimization. Based on the coking coal transport network of T iron & steel company, we propose a material dispatching scheme with MATLAB7.0 software compiling supply routes and dispatched quantity per batch and time for the supplier.

Key Words: Combinatorial optimization, material dispatching, supply priority, cost minimization

INRODUCTION

As for a company with continuous and mass production, its material suppliers are numerous and its geographical location is dispersed, such as T iron and steel company whose coking coal is provided by 22 suppliers through 28 stations(Assuming that the station and the supplier is one-to-one relationship, that is, supposing that supplier has two delivery stations: Sl_1 and Sl_2, then supplier S is divided into S_1 and S_2, where S_1delivers the goods at Sl_1, S_2 at Sl_2. Or supplier $S_1$and S_2 both deliver the goods at St, then the station St is divided into $St_1$and St_2, where S_1 delivers the goods at St_1, S_2 at St_2 and other circumstances with similar treatment).The space distribution of these stations is shown in Fig. 1 and the corresponding stations of serial number can be seen in http://ewebmail.mail.163.com. Because these suppliers and T iron and steel company have signed a contract and reached strategic partnership, each supplier requires the T iron & steel company to dispatch its material with priority at least once a production cycle. Here the main problem we try to solve is: Under the constraint of the material supply priority, the company properly arranges the material supply time and quantity of suppliers and avoids the simultaneous reaching of suppliers' material which can cause higher inventory and loading and moving burden and thereby leading to cost increase while meeting the demand, or avoids affecting the production continuity from insufficient inventory and the lack of timely replenishment of suppliers.

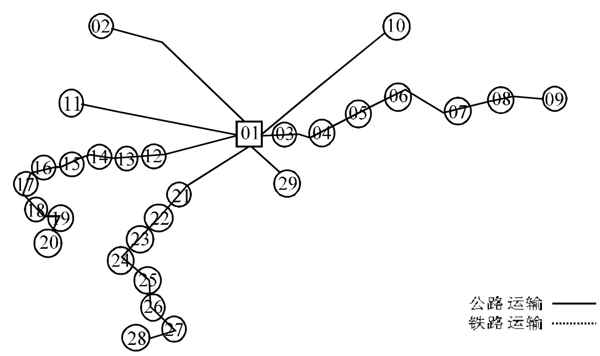

Fig. 1: Geographical location of 28 stations supplying coking coal in T iron and steel company

There are many optimization methods of material dispatching, such as transportation planning, shortest path method, min-cost max-flow method etc. (Guan and Zheng, 1983; Zhao, 1996; Hu, 1993). However, the given algorithm of each optimization method is based on satisfying specific conditions and these algorithms are used for solving specific problems accordingly. Yang *et al.* (2011) builds a mixed integer nonlinear

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programming model of liner fleet based on improving optimal configuration level of the liner transportation system and obtains the route-deployment, frequency of dispatching and optimization scheme of fleet construction in planning period. Qin *et al.* (2013) establish a mixed integer programming optimizing model. Li (2012) builds a multi-objective non-linear mixed integer programming model according to the specific circumstances of coal dispatching in S Group and solves the problem by genetic algorithm. Combining with material dispatching, emergency transportation and dynamic programming, Chen and Shuai (2010) investigate the transportation optimizing problem for emergency material under time window. Yuen (2007) studies a multi-objective supply planning problem under uncertain demand through introducing CVaR method. Chen and Liu (2012) solves an allocation problem of purchasing quantity with network analysis method when multiple suppliers supply the same material. Yu *et al.* (2011) and Liang *et al.* (2010) have performed related research on dispatching field of coal.

Due to the different supply capacity of coking coal suppliers, T iron & steel company should dispatch coking coal of one or more suppliers (called supply combination) in each supply period so as to meet the demand of production. According to contract between the company and supplier, the company should give priority to certain supplier's demand of production in this supply combination. Hence, the study mainly investigates the problem of material dispatching with supply priority. In supply combinations, the supplier with supply priority is called main supplier, the rest of suppliers are called auxiliary suppliers.

In material dispatching fields, some scholars also consider the selection of different transportation modes. Taking into account different means of transportation in the whole coal transportation network, Zhou and Ding (2011) establish a multi-objective programming model based on network flow whose objective function is related to transportation cost and time of multimodal transport and optimize it with genetic algorithm. Under the premise of considering both fixed transport cost and variable transport cost, Li *et al.* (2012) build a mixed integer linear programming model in allusion to a transportation mode optimizing selection problem of each section for a batch of goods on transportation route. Due to the strategic partnership between T iron and steel company and 22 suppliers of coking coal, the geographical location of each supplier is changeless, that is, each supplier selects the optimal transportation mode (whether unimodal transport or multimodal transport) in a production cycle when supplying T iron & steel company with coking coal. We assume that the transportation mode of each supplier is vested.

We mainly study the material dispatching problems with supply priority. In the research fields of material dispatching, the differences between this study and above scholars' research are as follows. First, the supplier for each kind of material serves as main supplier at least once a dispatching cycle of the company. Second, the transportation mode of supplier is vested when the company establishes the dispatching scheme of material. The study considers such factors: the production schedule, material inventory of the company, supply capacity, spatial and geographical distribution, supply priority of supplier, etc., establishes the model of material dispatching with supply priority and puts forward a material dispatching scheme with MATLAB7.0 software compiling supply routes and also dispatched quantity per batch and time for the supplier.

PRPBLEM DESCRIPTION AND NOTATIONS ASSUMPTIONS

Problem description: In practice, due to the restriction of production capacity or transport capacity for supplier, the material supply of single supplier often cannot meet the production demand. Hence, the single supplier should cooperatively constitute a supply combination with other suppliers and supply the company with material so as to guarantee the normal and continuous operation for production system of the company.

Supposing there are I suppliers supplying certain same material for a company. Each supplier has signed the contract with the company and the contract guarantees each supplier serving as main supplier at least one time in a dispatching cycle. These suppliers constitute different supply combination according to the vested supply routes and each supply combination supply the same material in accordance with certain rules. With the development of continuous production, the material of next supply combination just arrives when the material of the previous supply combination is consumed to safety inventory. The inventory variation with time of certain material is shown in Fig. 2, where t_k denotes the time when the inventory level reaches the safety inventory. $\Delta t_k = t_{k+1}-t_k$ denotes the supply period. Δj_{tk} denotes the time when batch j arrives within $[t_k,t_k+\Delta t_k]$. $M_{\delta tk}$ denotes the economic order quantity within $[t_k,t_k+\Delta t_k]$. $q_{\delta tkj}$ denotes the material supply arriving at $\Delta t_k j$. The total quantity:

$$\sum_{j=1}^{J_{\Delta t_k}} q_{\Delta t_k j}$$

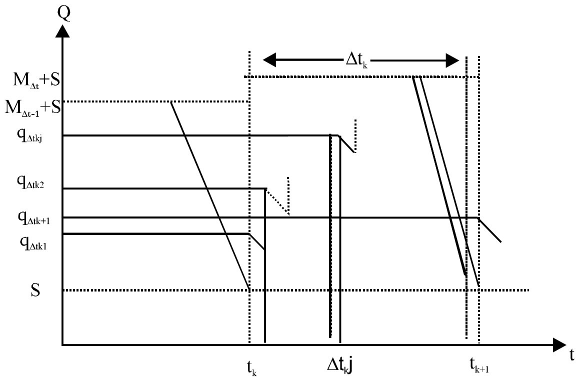

Fig. 2: Variation of material supply

are consumed to safety inventory after Δt_k. The first batch of material supply quantity $q\Delta_{tk+1}$ has just arrived with:

$$[t_{k+1}, t_{k+1} + \Delta t_{k+1}]$$

$$\left(k = 1, 2, \cdots, K, \cdots; i = 1, 2, \cdots, I J_{\Delta t_k} \in N^*\right)$$

Assumptions and notations:

- I: index set of suppliers, I = [1,...,i,...I]. where I,(i) denotes the supplier of number i. Assuming that the supplier does not change during a dispatching cycle
- S: safety stock of certain material
- $P_{\Delta t}$: average daily consumption of material within $[t_k, t_k+\Delta t_k]$

$P_{\delta t} = [P_1, ..., P_i, ...P_T]$ stands for production capacity set, where P_i denotes the average daily production capacity for supplier i supplying this kind of material within $|t_k, t_k+\Delta t_k|$.

- $ul_{\Delta t}$: Average daily offloading capacity for this kind of material within $|t_k, t_k+\Delta t_k|$
- $C_{\Delta t} = [C_1, ..., C_i, ..., C_T]$ is cost set, where C_i denotes unit transportation cost for supplier i transporting this kind of material with certain vested transportation mode within $|t_k, t_k+\Delta t_k|$
- $V_{\delta t} = |V_1, ..., V_i, ...V_T|$ is the speed set, where V_i denotes the average transportation speed for supplier i transporting this kind of material with certain vested transportation mode within $[t_k, t_k+\Delta t_k]$
- D_0: The start date to consume this kind of material of the company's production. D_1: The expiry date not to consume this kind of material of the company's production. We assume the company always consumes this kind of material in the process of production. $D = [d_1, ...d_i, ...d_T]$ is time set, where d_i denotes the start time for supplier i producing this kind of material and here we also assume that the supplier always meets the demand in the process of the company's production
- K: Supply times of material in dispatching cycle and K satisfies:

$$K \in \left\{K' \left| \sum_{k=1}^{K'-1} \Delta t_k < D_1 - D_0; \sum_{k=1}^{K} \Delta t_k \geq D_1 - D_0; K' \in N^* \right.\right\}$$

- $q_\cap$: The inventory level of this kind of material in the beginning of the company's production. $Q_n = |q_{n1}, ..., q_{n2}|$ is the initial inventory set, where q_n denotes the inventory level for supplier I supplying the company with this kind of material at the first time
- $L_{\Delta t} = |l_1, ..., l_i, ...l_T|$ is spatial distance set, where l_i denotes the spatial distance between supplier i and the company within $|t_k, t_k+\Delta t_k|$. (Since, the change of transportation mode can alter the spatial distance between)
- $X_{\Delta t}$: Supply matrix set which is shown as follows:

$$X_{\Delta t_k} = \left\{\left[1, m^1, \cdots, h^1\right] \cdots, \left[i, m^i, \cdots, h^i\right], \left[m^i, i \cdots, h^i\right], \cdots \left[I, m^I, \cdots, h^I\right]\right\}$$

where, $[i, m^i, ...h^i]$ denotes the supply combination for supplier $i, m^i, ...h^i$ in the same route and i serving as the main supplier within $[t_k, t_k+\Delta t_k]$. Each supplier is sorted in ascending order of spatial distance except for the main supplier in each supply combination and the main supplier is located in the first column of the matrix:

$$Y_{\Delta t_k i} = \begin{cases} 1 \text{if supplier i supplies material and the j batch arrives at } [t_k, t_k + \Delta t_k] \\ 0 \text{others} \qquad k = 1, 2, \cdots, K; i = 1, \cdots, I \end{cases}$$

$J_{\Delta tk}$: Total dispatching batch within $[t_k, t_k+\Delta t_k]$, namely:

$$J_{\Delta t_k} = \begin{cases} \dfrac{M_{\Delta t_k}}{ul_{\Delta t_k}}, ul_{\Delta t_k} \mid M_{\Delta t_k} \\ \left\lfloor \dfrac{M_{\Delta t_k}}{ul_{\Delta t_k}} \right\rfloor + 1 ul_{\Delta t_k} \nmid M_{\Delta t_k} \end{cases}$$

where, $x|y$ denotes that y can be divisible by $x|y$, denotes that y cannot be divisible by $x, _{[x]}$ denotes down round.

- Assuming:

$$\Delta t_{k-1} + \frac{S}{ul_{\Delta t_k}} \geq \frac{L_{\Delta t_k}(i)}{V_{\Delta t_k}(i)} \forall i \in [1, I], \ (k = 1, 2, \cdots, K)$$

- Supposing the unit wholesale price for all the suppliers is the same, here we don't consider the supplier's removal or dock cost at each station

DISPATCHING MODELD

A proper material dispatching scheme not only satisfies the production demand at any time but also meets the minimizing of transportation cost, namely we must consider the trade-off between transportation cost and inventory cost. Hence, dispatching model of this study obeys the following two basic rules: the continuity of production and the minimizing of transportation cost.

Decision variables: In each supply period, the company can select proper supplier from numerous suppliers and in order to satisfy the stability, continuity and economical efficiency. Let $q_{\Delta t_i}$ be decision variable which denotes the dispatching quantity that supplier i can supply and reach within$\Delta t_k j$.

Constraint conditions:

- Total dispatching quantity constraint

$$M_{\Delta t_k} - \sum_{j=1}^{J_{\Delta t_k}} \sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} = 0, \left(k = 1, \cdots, K\right)$$

- Each supplier's supply capacity constraint

$$Q_{t_{k-1},i} \geq \sum_{j=1}^{J_{\Delta t_k}} q_{\Delta t_k j_i}, \left(k = 1, \cdots, K; i = 1, \cdots, I\right)$$

where, $Q_{tk-1,i}$ denotes the stocking quantity of supplier i at t_{k-1}:

$$Q_{t_{k-1},i} = Q_0\left(i\right) + \sum_{e=1}^{k-1} \left(t_e - t_{e-1}\right) P_{\Delta t_e}\left(i\right) - \sum_{e=1}^{k-1} \sum_{j=1}^{J_{\Delta t_k}} q_{\Delta t_e j_i},$$

$$\left(k = 2, \cdots, K; i = 1, \cdots, I; t_0 = D_0\left(i\right)\right)$$

- Continuous production constraint

$$\sum_{w=1}^{j} \sum_{i=1}^{I} q_{\Delta t_k w_i} Y_{\Delta t_k w_i} + S - \left(\Delta t_k j - t_k\right) p_{\Delta t_k} > 0, \left(k = 1 \cdots, K; j = 1, \cdots, J_{\Delta t_k}\right)$$

$$q_{\Delta t_{k+1} 1} + \sum_{j=1}^{J_{\Delta t_k}} \sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} - \left(t_{k+1} - t_k\right) p_{\Delta t_k} \geq S, \left(k = 1, \cdots, K\right)$$

- Average daily offloading capacity constraint:

$$\left(\Delta t_k\left(j+1\right) - \Delta t_k j\right) ul_{\Delta t_k} - \sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} \geq 0, \left(j = 1, \cdots, J_{\Delta t_k} - 1\right)$$

- Contract constraint:

$$I_S - I_{t_k} \neq 0, \left(k = 1, \cdots, K\right)$$

where, I and L have the same dimension, if supplier m has already served as the main supplier before t_k, then $I_{tk}(i) = i$, otherwise $I_{tk}(i) = 0, i \neq i$.

- Transportation capacity constraint:

$$q_{\Delta t_k j, w} \leq CW_{\Delta t_k j} q_{\Delta t_k j, v} \leq CV_{\Delta t_k j}$$

where, $q_{\Delta t,iw}$ denotes the weight of material arriving the company at $\Delta t_k j$, $CW_{\Delta t,j}$ denotes the maximum weight capacity of vehicle, $q_{\Delta t,iv}$ denotes the volume of material arriving the company at $\Delta t_k j$, $GV_{\Delta t,i}$ denotes the vehicle's maximum volume.

- Non-negativity constraint of parameters:

$$q_{\Delta t_k j_i} > 0, \left(k = 1, \cdots, K; j = 1, , J_{\Delta t_k}; i = 1, \cdots, I\right)$$

Optimization goal:

- Transportation cost C:

$$C = \sum_{k=1}^{K} \sum_{j=1}^{J_{\Delta t_k}} \sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} C_{\Delta t_k, i}\left(i\right) L\left(i\right)$$

- Transportation time T:

$$T = \sum_{k=1}^{K} \sum_{i=1}^{I} \sum_{j=1}^{J_{\Delta t_k}} \frac{L\left(i\right)}{V_{\Delta t_k, i}\left(i\right)} Y_{\Delta t_k j_i}$$

- Vehicle utilization rate U:

$$U = \sum_{k=1}^{K} \sum_{j=1}^{J_{\Delta t_k}} \max\left\{\frac{q_{\Delta t_k j, w}}{CW_{\Delta t_k j}}, \frac{q_{\Delta t_k j, v}}{CV_{\Delta t_k j}}\right\}$$

Dispatching optimization model: The optimization model of material dispatching is a multiobjective optimization problem. We assume that the decision maker of the company gives priority to transport cost, then vehicle utilization and finally the transit time after satisfying the constraint conditions in section3.2.

Definition1: Let A be the decision value, B be the target value, then positive deviation variable d^+ and negative deviation variable d^- are defined as follows:

$$d^+ = \begin{cases} A - B, A \geq B \\ 0, \text{others} \end{cases} \quad d^- = \begin{cases} 0, \text{others} \\ B - A, A \leq B \end{cases}$$

Then in the dispatching optimization model of section 2.4, the minimum transport cost is the first precedence level goal. We introduce the decision value g_c

and generate the goal constraint $C+d^-_1-d^+_1 = g_c$. The objective function with positive deviation variable should be small as soon as possible , namely d^+_1. The minimum transit time is the third precedence level goal. We introduce the decision value g_T and generate the goal constraint $T+d^-_2-d^+_2 = G_T$. The objective function with positive deviation variable should be small as soon as possible , namely d^+. The maximum vehicle utilization is the second precedence level goal. We introduce the decision value g_u and generate the goal constraint $U+d^-_3-d^+_3 = g_u$. The objective function with negative deviation variable should be small as soon as possible , namely $\min d^-_3$. We also introduce the priority coefficient denoting target precedence level $P_1,P_2, P_3(P_1>>P_2>>P_3)$ and multiply them ahead of each objective, respectively, then the dispatching optimization model can be converted to:

$$
\text{s.t.}\begin{cases}
\sum_{k=1}^{K}\sum_{j=1}^{J_{\Delta t_k}}\sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} C_{\Delta t_k,i}(i) L(i) + d_1^- - d_1^+ = g_C \\
\sum_{k=1}^{K}\sum_{i=1}^{I}\sum_{j=1}^{J_{\Delta t_k}} \frac{L(i)}{V_{\Delta t_k,i}(i)} Y_{\Delta t_k j_i} + d_3^- - d_3^+ = g_T \\
\sum_{k=1}^{K}\sum_{k=1}^{K}\sum_{j=1}^{J_{\Delta t_k}} \max\left\{\frac{q_{\Delta t_k j,w}}{CW_{\Delta t_k j}}, \frac{GV_{\Delta t_k j,v}}{CV_{\Delta t_k j}}\right\} + d_2^- - d_2^+ = g_U \\
M_{\Delta t_k} - \sum_{j=1}^{J_{\Delta t_k}}\sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} = 0 \\
Q_{t_{k-1},i} \ge \sum_{j=1}^{J_{\Delta t_k}} q_{\Delta t_k j_i} \\
\sum_{w=1}^{j}\sum_{i=1}^{I} q_{\Delta t_k w_i} Y_{\Delta t_k w_i} + S - (\Delta t_k j - t_k) p_{\Delta t_k} > 0 \\
q_{\Delta t_{k+1} 1} + \sum_{j=1}^{J_{\Delta t_k}}\sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} - (t_{k+1} - t_k) p_{\Delta t_k} \ge S \\
(\Delta t_k (j+1) - \Delta t_k j) ul_{\Delta t_k} - \sum_{i=1}^{I} q_{\Delta t_k j_i} Y_{\Delta t_k j_i} \ge 0 \\
I_S - I_{t_k} \ne 0 \\
q_{\Delta t_k j,w} \le CW_{\Delta t_k j} \\
q_{\Delta t_k j,v} \le CV_{\Delta t_k j} \\
q_{\Delta t_k j_i} > 0, k=1,\cdots,K; j=1,,J_{\Delta t_k}; i=1,\cdots,I
\end{cases}
$$

MODEL SOLUTION

Model analysis: This study mainly solve the joint scheduling problem with contract constraint. So, we first determining of the various outlets supply combination as well as the supply of each combination of dynamic inventory according to geographic location; And then we determining supply combination and main supply by optimization goal; Finally this study propose a material dispatching scheme and dispatched quantity per batch and time for the supplier.

So, the solving algorithm for dispatching optimization model of section §2.4 can be divided into five procedures: (1) Initializing data. (2) Calculating total inventory of supply routes. (3) Classifying total inventory

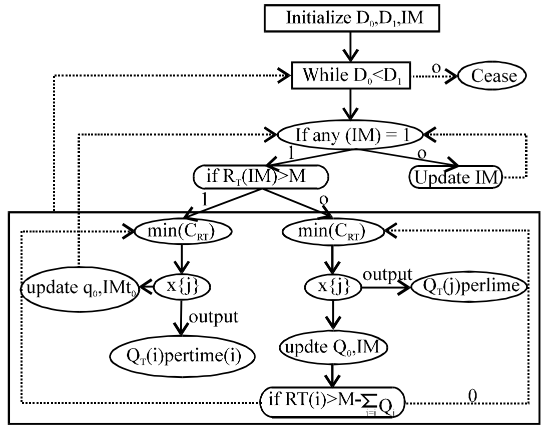

Fig. 3: Aterial scheduling algorithm structure based on MATLAB

of supply routes. (4) Judging the opening and closing of4 supply cycle., (5) Confirming dispatching scheme of material. The algorithm structure is shown in Fig. 3.

Algorithm design: The specific procedures of the algorithm are as follows:

Procedure 1: Initializing data: When K = 1, let I = [0,...,0,...,0], $IM = I_s$-I, then initializing the following data: I_S,D_0,D_1,Q_2

Procedure 2: Calculating total inventory of supply route: When the company is making dispatching decision,we get the latest departure time T of supplier I when i arrives at the company and the company's inventory quantity is:

$$
S: T = \left[\text{datenum}(D_0) + \frac{\max(q_0 - S, 0)}{p_{\Delta t_k}} - \frac{L_{\Delta t_k}(i)}{V_{\Delta t_k}(i)}\right], i=1,\cdots,I; k=1,\cdots,K
$$

where, datenum x convert the character x into the numeric.

Q_T denotes each supplier's inventory quantity at T(i) on the route that the supplier i serving as the main supplier:

$$
Q_T = \left\{[q_1, q_{m^1} \cdots, q_{h^1}], \cdots, [q_i, q_{m^i}, \cdots, q_{h^i}], \cdots, [q_n, q_{m^n}, \cdots, q_{h^n}]\right\}
$$

Where:

$$
q_j = \max(Q_0(j), 0) + \max(\min(T(i), T(j)) - D_0(j), 0) \times P_0(j); j \in [i, m^i, \cdots, h^i]
$$

R_r denotes the total inventory quantity of supply route where and when supplier i serving as main supplier at T(i):

Table 1: Coking coal dispatching scheme of T iron and steel company

Main supplier	Supply combination	Supply quantity	Batch departure time	Total cost
4	[4]	[5]	2013-11-30	83.70
			2013-12-01	
5	[5]	[5]	2013-12-05	92.05
			2013-12-06	
6	[6,4,3]	[0.6681,0.5377,3.7941]	2013-12-10	115.11
			2013-12-10	
			2013-12-10	
			2013-12-11	
7	[7,4,3]	[0.7055,0.4344,3.8600]	2013-12-15	132.68
			2013-12-15	
			2013-12-15	
			2013-12-16	
8	[8,4,3]	[0.5913,0.4865,3.9222]	2013-12-20	138.86
			2013-12-20	
			2013-12-20	
			2013-12-21	
9	[9,4,3]	[0.6095,0.4118,3.9787]	2013-12-24	190.29
			2013-12-24	
			2013-12-24	
			2013-12-25	
35	[35,29]	[1.5265,3.4735]	2013-12-31	229.94
			2013-12-31	
			2014-01-01	

$$R_T = \left[\sum_{[i,m^i,\cdots,h^i]} q_k \right]; 1 \le i \le I, k \in \left[i, m^i, \cdots, h^i \right]$$

Procedure 3: Classifying total inventory of supply routes: We classify the total inventory of supply routes into two types:

$$R_T = \{R_1, R_2\} R_1 = \left[q_{s_1}, \cdots, q_{s_i}, \cdots, q_{s_a} \right] R_2 = \left[q'_{s_1}, \cdots, q'_{s_j}, \cdots, q'_{s_b} \right]$$

For any S_i,q_{si}<M, for any S_j,M≤$q`_{si}$, Corresponding to R_T,Q_T is also divided into two types, namely $Q_T = \{Q_{T1}, Q_{T2}\}$.

Procedure 4: Judging the opening and closing of supply cycle: If any (IM) = 0, then move to procedure1. Otherwise, move to procedure5.

Procedure 5: Confirming dispatching scheme of material:

- If isempty (R_2)≠0, we can select the supply combination where j serving as main supplier in Q_{T2} according to the principle of continuous production and cost minimization. The selection method of supply combination and the scheme design of each supplier's departure time and dispatching quantity for each batch are shown in Appendix A
- If isempty (R_2) = 0, isempty (R_1)≠0, then we need continuously dispatch the supply combination from different routes. At this point, the selection method of supply combination and the scheme design of each supplier's departure time and dispatching quantity for each batch are shown in Appendix B

CASE ANALYSIS

The demand of coking coal for T iron and steel company is supplied by 28 suppliers, the basic information of each supplier is shown in http://ewebmail.mail.163.com According to the supplier's geographical location and mode of transportation in Fig. 1, we obtain the supply combination X.

On the grounds of the above algorithm of dispatching model, we establish the dispatching scheme of T iron & steel company with MATLAB7.0 software in Dec. 2013. The dispatching scheme is shown in Table 1. The other related information and MATLAB program of the numerical example can download from http://ewebmail.mail.163.com. Username: study _D_F@163.com, Password: studydf .

CONCLUSIONS

To meet the demand of normal and continuous production, we establish a model and algorithm of material dispatching and schedule a material dispatching scheme according to the minimum standard satisfying normal production and transport cost and also combining with the factors such as production planning, material inventory quantity of the company, spatial and geographical distribution, the priority of the supplier. Finally we compile a dispatching scheme with MATLAB7.0 software for T iron & steel company in Dec. 2013:

- T iron and steel company previously works out the dispatching scheme of material by experience. Through the model and algorithm of material dispatching in this study, we can easily make a dispatching scheme, save the labor cost and improve the work efficiency
- The dispatching scheme compiled by model and algorithm clearly confirms the departure time and dispatching quantity per batch for each supplier and is convenient for supplier to arrange production planning
- On the basis of supplier's priority, the dispatching scheme can save the logistics cost to a large extent for the supply system composed by T iron and steel company and suppliers

APPENDIX

Appendix A: If isempty (R_2)≠0, we can select the supply combination where j serving as main supplier in Q_{T2} according to the principle of continuous production and cost minimization. The scheme design is as follows:

Assuming the supply combination from R_2 is $X_2\{j\}$ = [j-m^j...h^j]. The total dispatching quantity of this time is M, the transport batch is:

$$Z=\begin{cases} M/ul, ul|M \\ round(M/ul)+1, others \end{cases}$$

Let L_{Ti} = length (Q_{T2i}),$q_{T(n)}$ = 0. Then the supply quantity of supplier j,m_j,...,h_j is

$$q_{x(i)}=\min\left(M-\sum_{x(k)} q_{x(k)}, Q_{T2j}(i)\right); i=1,2,\cdots,L_{Tj}, k=0,1,\cdots,i-1$$

Which satisfies:

$$\sum_{x=[j,m^j,\cdots,h^j]} q_e = M, q_e \neq 0; e=x(i), i=1,2,\cdots,\text{length}(x)$$

Calculating the cost C_{T2} of Q_{T2}, where:

$$C_{T2}(i)=\sum_{x=[j,m^j,\cdots,h^j]} C_{x(k)} \times q_{x(k)} \times L_{x(k)}$$

$$k=1,2,\cdots,\text{length}(x), i=1,2,\cdots,\text{length}(X_2)$$

Select the main supplier $j \leftarrow \min(C_{T2})$ according to cost minimization.

By ranking spatial distance between suppliers and the company in descending order, we get X′{j}, then departure batch Z_e of supply e can be obtained from below:

$$\text{Let } s_{q_e}=\frac{\sum_{e'} q_{e'}}{ul}-\text{round}\left(\frac{\sum_{e'} q_{e'}}{ul}\right), Z_e=\begin{cases} \frac{s_{q_e}+q_e}{ul}, & ul|(s_{q_e}+q_e) \\ \text{round}\left(\frac{s_{q_e}+q_e}{ul}\right)+1, & \text{others} \end{cases}$$

The departure time of supplier e is:

$$T_{Xj}^{e}=\begin{cases} \sum_{e'} T_{Xj}^{e'}, s_{q_e}=0 \\ \sum_{e'} T_{Xj}^{e'}-1, \text{others} \end{cases}$$

and the corresponding dispatching quantity are: ul-s_{qe} denotes the quantity at first time, min (q_e-z_e×ul,ul) indicates the quantity at last time, ul denotes the quantity at middle time:

$$\text{Where } e=X'\{j\}(i),\ e'=X'\{j\}(k)$$

$$i=1,2,\cdots,\text{length}(X'\{j\}), k=0,1,\cdots,i-1$$

Update the following data in sequence:

$$I(j)=0;\ q_0=M+S;\ Q_0=\begin{cases} Q_0(e), e \notin X\{j\} \\ Q_0(e)-q_e, e \in X\{j\} \end{cases};\ D_0=D_0+\frac{q_0}{p_0}$$

If I = 0, then a supply cycle is over and move to procedure 1. Otherwise, move to procedure 2.

Appendix B: If isempty (R_2) = 0, isempty (R_1)≠0 then we need continuously dispatch the supply combination from different routes. The scheme design is as follows:

Let Sum R_1 = 0:

- The total cost C_{T1} of each supply route can be calculated according to Q_{T1}, the supply route |i,m^i,...h^i| that i serving as main supplier can be selected in accordance with the rule of minimum cost and the supply quantity of the route is Sum R_1 = sumR_1 = sumR_1+R_1(i), then updating q $_n$ and recalculating R_T
- If there exists R_T(i)≥M-sum R_1;≠i, then we select the supply combination according to method (1), at this point, we have M = M-sum R_1

Otherwise, continuously circulating (1), until there successively exists [I, j,...v,u] (note that [j,...v,u] cannot serve as main supplier.) and satisfies:

$$\sum_r R_T(r) < M \leq \sum_r R_T(r)+R_T(u); r \in [i,j,\cdots,v]$$

Now the corresponding supply quantity for supply route that |i,...,v| serving as main supplier is R_T(r), the supply quantity of supply route that u serving as main supplier is:

$$R_T'(u)=\min\left(M-\sum_r R_T(r), R_T(u)\right),\ r \in [1,\cdots,v]$$

The ultimate supply combination selected from X_1 is:

$$X\{i,\cdots,v,u\}=\left\{\left[i,m^i,\cdots,h^i\right],\cdots,\left[v,m^v,\cdots,h^v\right],\cdots,\left[u,m^u,\cdots,h^u\right]\right\}$$

We confirm the departure time and dispatching quantity per batch for each supplier according to [I,...,v,u] in sequence and the calculating method is same as Appendix A.

According to the dispatching quantity per batch for each supplier, we calculate the total dispatching cost C_{T1} for this time and the calculating method is same as Appendix A.

Update the following data in sequence:

$$I(i) = 0;\ q_0 = M + S;\ Q_0 = \begin{cases} Q_0(e), e \notin X\{i, \cdots, v, u\} \\ Q_0(e) - q_e, e \in X\{i, \cdots, v, u\} \end{cases};\ D_0 = D_0 + \frac{q_0}{p_0}$$

If I = 0, then a supply cycle is over and move to procedure 1. Otherwise, move to procedure 2.

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