ISSN : 0974 - 7435 Volume 10 Issue 24

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(24), 2014 [15318-15323]

Production planning based on mathematics methods and software technology

Jianjun Yu[1], Wenguang Liang[1*], Jing Zha[2],
[1]School of Business Administration, South China University of Technology, Guangzhou, 510640, (CHINA)
[2]College of Mechanical & Material Engineering, Three Gorges University, Yicang, 443002, (CHINA)
E-mail: npuxiaoyu@126.com

ABSTRACT

Production planning can help companies reduce the production costs and increate the benefits. But it is very difficult engineering problem. The production problem of a manufacturer group is described and analyzed. Then its production planning mathematics models are set up. The production planning problem is converted into transportation problem, and it is imbalance in production and marketing. After it is analyzed and excess production capacity is considered, the imbalance transportation problem is converted into standard transportation problem. Then several mathematics methods and software tools are adopted to solve it. Finally the optimal solution is obtained after much alternation and calculation. The best production scheme with minimum total cost of production is formulated for the manufacturer group, accordingly a lot of cost is reduced for the group.

KEYWORDS

Production planning; Optimal solution; Transportation problem; Initial basic feasible solution.

INTRODUCTION

Good production planning can help companies save production costs, and reap more benefits. Therefore, it is very important. Production planning researches has attracted the attention of many scholars. Kirna[1] summarized the research status in a dynamic environment based production arrangement. Montazeri[2] studied the production rule, and analyzed the average waiting time of these rules for an actual FMS. Doublgeri[3] studied methods based on knowledge for flexible PCB example.

Mathematical programming is one of the main methods of production planning. Voudouris [4] studied the batch process scheduling problems and established a complex MILP model, and proposed several simplified method for solving. Pinto[5] presented a continuous time MILP model focused on short-term scheduling problem of parallel devices.

PROBLEM BACKGROUND

BetterLife Group has three production bases, producing small household electrical appliances with own brand, and also provide OEM service. Recently the company got abroad OEM orders include 40,000 coffee machines, 30,000 cookers, 30,000 electric fans and 20,000 dehumidifiers. The company must arrange the task in the processing line of three production bases at the same time in order to deliver on time in accordance with the contract requirements.

According to the data provided by the production planning department, the company is now able to provide three production bases within the production capacity of 7.5 million units, 7.5 million units and 4.5 million units. Although these products are different, the company's production line and skilled workers can produce no difference because it has much OEM experience. The production cost of every product in every production base is shown as Table 1.

Table 1: Production cost of every product in every production base

Product / Unit Cost / Place	A	B	C	D	Production capacity (10,000 units)
1	82	54	56	48	7.5
2	80	58	-	46	7.5
3	74	60	54	42	4.5
Demand (10,000units)	2	4	3	3	

Here, Product A represents dehumidifiers, Product B represents coffee machine, Product C represents the fans, Product D represents cooker.

The company must determine the optimal production schedule according to the above-described production costs, and production capacity.

ESTABLISHMENT OF MODEL

The problem is to determine the optimal production plan for BetterLife group according to given production costs, and production capacity. a_i represents the production capacity of Base i. b_j represents the demand for Product j. c_{ij} represents the production cost of Base i for Product j. Above problem can be abstracted as a transportation problem, namely transport some goods from 3 production bases to 4 sale places, c_{ij} represents the unit transport costs from Base i to sale place j. a_i represents production volume of Base i, b_j represents the sales volume of sale place j. i=1,2,3 and j=1,2,3,4. Need to find out the transportation solution with minimum total cost. x_{ij} represents the transportation volume from Base i to sale place j.

Programming model for this problem is set up as follows:

$$\min z = \sum_{i=1}^{3} \sum_{j=1}^{4} C_{ij} x_{ij}$$

$$s.t \quad \begin{cases} \sum_{j=1}^{4} x_{ij} \le a_i, (i = 1,2,3) \\ \sum_{i=1}^{3} x_{ij} = b_j, (j = 1,2,3,4) \\ x_{ij} \ge 0 \end{cases}$$

Because the total production capacity $\sum_{i=1}^{3} a_i$ =195000 unit, and the total demand $\sum_{j=1}^{4} b_j$ =120000 unit ,therefore the problem is imbalance in production and marketing, and it's not the standard transportation problem. So it needs to be analyzed and excess production capacity needs to be considered. The idea is to convert imbalance transportation problem into standard transportation problem. Suppose x_{i5} is the quantity of excess product of Base *i*.

$$\sum_{i=1}^{3} x_{i5} = \sum_{i=1}^{3} a_i - \sum_{j=1}^{4} b_j = b_5 = 75000$$

Let $C'_{\mathrm{ij}} = C_{ij}$, when $i = 1,2,3;\ j = 1,2,3,4$;

Let $C'_{\mathrm{ij}} = 0$, when $i = 1,2,3;\ j = 5$;

Substitute them into the model, and get production-sale balance model:

$$\min z' = \sum_{i=1}^{3}\sum_{j=1}^{5} C'_{\mathrm{ij}} x_{ij} = \sum_{i=1}^{3}\sum_{j=1}^{4} C_{\mathrm{ij}} x_{ij}$$

$$s.t \quad \begin{cases} \sum_{j=1}^{5} x_{ij} = a_i, (i = 1,2,3) \\ \sum_{i=1}^{3} x_{ij} = b_j, (j = 1,2,3,4\ 5) \\ x_{ij} \geq 0 \end{cases}$$

SOLUTION PROCEDURE

Since the total production capacity is greater than the total demand, therefore suppose that excess production capacity is used to produce Product E, and the production cost is 0 according to above analysis.

Determine the use of smallest element method to get the initial basic feasible solution, the basic idea of this method is low cost principle. First of all, the production relation with minimum unit cost is deterred, then the bigger, and so on, until the initial basic feasible solution is obtained.

Step 1：Find the minimum production cost is 0. Here the production cost Product E is 0, and randomly select one. Product E is arranged at Base 2. Because of a_2=b_5, the production capacity of Base 2 has saturated after the production of Product E. In this case, the degradation phenomenon appears.

Step2：When degraded, 0 must be filled in the corresponding grid to indicate that this is the digital cell. After 7.5 is filled in grid (2,5), a_2=b_5. Accordingly fill in a number of sales in the balance sheet, and then cross out the corresponding row and column of the unit cost table with line. In order to make the balance sheet has 7 digital cells, need to add a 0. Optionally select a cell from the space cell (1,5), (3,5), (2,1), (2,2), (2,3), (2,4), and fill 0 into it. In this problem, fill 0 into (2, 4).

Step3：The new minimum cost is 42 in the rest of the elements. The excess production capacity of Base 3 after production of the D is 15,000 units.

Step4：The new minimum cost is 54 in the rest of the elements. Then continue according to above rule step by step, until all elements in the unit cost table have been struck out. Finally, get a scheme on the balance sheet which is the initial basic feasible solution.

Table 2: Initial solution

Product / Unit Cost / Place	A	B	C	D	E	Production capacity (10,000 units)
1	2	4	1.5			7.5
2				0	7.5	7.5
3			1.5	3		4.5
Demand (10,000 units)	2	4	3	3	7.5	19.5

According to the initial scheme, the company's total production cost is 6.71 million RMB.

Use dual variable method to check and determine the optimal solution. To judge whether the basic feasible solution is the optimal solution, need to calculate all non-basic variable inspection numbers.

Make Table 3 according to the initial solution is given by the smallest element method. Fill the corresponding unit costs.

Table 3: Solution Check

Product / Place	A	B	C	D	E	a_i	u_i
1	$\boxed{82}$ 2	$\boxed{54}$ 4	$\boxed{56}$ 1.5	$\boxed{48}$	$\boxed{0}$	7.5	0
2	$\boxed{80}$	$\boxed{58}$	$\boxed{M}$	$\boxed{46}$ 0	$\boxed{0}$ 7.5	7.5	2
3	$\boxed{74}$	$\boxed{60}$	$\boxed{54}$ 1.5	$\boxed{42}$ 3	$\boxed{0}$	4.5	-2
b_j	2	4	3	3	7.5	19.5	
v_j	82	54	56	44	-2		

In the Table 3, the dual variable valuing process is as follows: firstly, determine the value of u_1, let u_1=0, then v_1, v_2, v_3 can be calculated, and their values are respectively 82, 54, 56. and then determine u_3=-2, v_4=44, u_2=2. Secondly, use formula $\sigma_{ij} = C_{ij} - (u_i + v_j)$ to calculate all non-basic variable inspection numbers.

Table 4: Inspection numbers of dual variable method

Product / Unit Cost / Place	A	B	C	D	E
1				4	2
2	-4	2	M-58		
3	-6	8			4

There are two negatives in inspection number table, so the basic feasible solution is not optimal, and the result still needs to be adjusted.

Using closed loop adjustment method to improve the feasible scheme. There are two negatives in inspection number table. Select the smallest negative number which is -6, and consider its corresponding space cell (3, 1) as into-cell, that is, the corresponding non-basic variable is considered as into-variable. Then make a closed loop.

Table 5: Closed loop adjustment-I

A	B	C	D	E	a_i
2 (-1)	4	1.5 (+1)			7.5
			0	7.5	7.5
(+1)		1.5 (-1)	3		4.5
2	4	3	3	7.5	19.5

The into-transfer value θ of space cell (3,1) is the smallest one of all cells with (-1) in the closed loop. Namely, $\theta = \min\{1.5,2\} = 1.5$. Then add or subtract 1.5 according to positive sign or negative sign of cell in the closed loop, and obtain adjustment scheme as Table6.

Table 6: Closed loop adjustment-II

Product Unit Cost Place	A	B	C	D	E	Production capacity (10,000 units)
1	0.5	4	3		0	7.5
2					7.5	7.5
3	1.5			3		4.5
Demand (10,000 units)	2	4	3	3	7.5	19.5

If arrange production according to above table, the company's total production cost is 6.62 million RMB. Repeat according to dual variable method to judge optimal solution. Then the dual variable inspection numbers are obtained as follows.

Table 7: Closed loop adjustment-III

Product Unit Cost Place	A	B	C	D	E
1				-2	0
2	-2	4	M-56	-4	
3		14	6	8	4

There are 3 negatives in inspection number table, so the basic feasible solution is not optimal, and still need to be adjusted.

Table 8: Closed loop adjustment-IV

A	B	C	D	E	Production capacity (10,000 units)
0.5 (-1)	4	3		0 (+1)	7.5
			(+1)	7.5 (-1)	7.5
1.5 (+1)			3 (-1)		
2	4	3	3	7.5	19.5

The into-transfer value θ of cell (4, 2) is the smallest one of all cells with (-1) in the closed loop. Namely, $\theta = \min\{0.5,3,7.5\} = 0.5$. Then add or subtract 0.5 according to positive sign or negative sign of cell in the closed loop, and obtain adjustment scheme as Table 9.

Use dual variable method to judge optimal solution. All non-basic variable test numbers are positive, so the basic feasible solution is optimal.

Table 9: The optimal production plan

Product Unit Cost / Place	A	B	C	D	E	Production capacity (10,000 units)
1		4	3		0.5	7.5
2				0.5	7	7.5
3	2			2.5		4.5
Demand (10,000units)	2	4	3	3	7.5	19.5

The company arranges Base 1 produce 40,000 coffee machines and 30,000 fans, Base 2 produce 5,000 cookers, Base 3 produce 20,000 dehumidifiers and 25000 cookers. Based on the best production arrangements, the company's total production cost is 660 million RMB.

In addition, use lingo software to solve the problem. Enter the following code in the lingo software.

```
Model:
sets:
supply/1..3/:produce;demand/1..4/:sell;
link(supply,demand):cost,x;endsetsdata:
cost=82 54 56 48
 80 58 1000 46
 74 60 54 42;
produce=7.5 7.5 4.5
sell=2 4 3 3;
enddatamin=@sum(link:cost*x);   @for(supply(i):@sum(demand(j):x(i,j))<=produce(i));
@for(demand(j):@sum(supply(i):x(i,j))=sell(j));
End
```

The calculation results:

x_{12}=4, x_{13}=3, x_{24}=0.5, x_{31}=2, x_{34}=2.5

The objective function value is 6.6 million RMB, which is accord with the result based on the tabular method.

CONCLUSION

In order to make the lowest total cost of production, BetterLife Group should arrange Base 1 that has a considerable scale of industrial clusters and lie in southern China produce 40,000 coffee machines and 30,000 fans.

Base 2 that near the port of trade has an advantage in the international logistics, but it can't produce electric fan, therefore, arrange it only produce 5,000 cookers.

Base 3 in the country of western development, has a relatively low labor and can get benefits and compensation aspects of government revenue. Therefore it has lower production costs, but its production capacity is relatively small, so we chose to fully utilize its production capacity, production schedule 2 dehumidifier million units, 25,000 dehumidifiers. In general, under the optimal production plan, the total cost to complete the order BetterLife Group need to spend 660 million RMB.

ACKNOWLEDGMENTS

This project is supported by NSFC (71071059, 71301054), training plan of Guangdong province outstanding young teachers in higher education institutions (Yq2013009). the Fundamental Research Funds for the Central Universities (2014X2D03).

REFERENCES

[1] Kiran A.S., Smith M. L., Simulation studies in job shop scheduling-I a survey, Computer and Industry Engineering, 1984,8(2),87

[2] Montazeri M., Van Wassehove L. N., Analysis of scheduling rules of an FMS, International Journal Product Research, 1990,28(4),785

[3] Wu Jianyu, He xiaorong, chen Bingzhen, Qiu Tong. A new continuous time MILP model for scheduling of multi product batch plants. Journal of Chemical Industry & Engineering(China), 2003, 54（9） : 1250-1256

[4] Voudouris V. T. Grossman I. E. MILP model for scheduling and design of a special class of multipurpose batch plants. Computer & Chemical Engineering. 1996. 20(11):1336-1360

[5] Pinto J. M. Grossman I. E. Alternate MILP model for short term scheduling of batch plants with pre ordering constraints. Industrial & Engineering Chemistry Research, 1996, 35(1): 338 342