



OPTIMIZATION OF PRODUCTION PLANNING IN MANUFACTURING SECTOR: A CASE STUDY

Harwinder Singh
Raman Kumar

Abstract

Now a day, manufacturing industry is focusing to optimize the supply-chain activities in order to survive in the competitive scenario. In the present study, an attempt has been made to optimize the production planning using linear programming. The production planning problem is transformed into linear programming, and the objective function is formulated, which consist of both production cost and holding cost. The constraints of the objective function of case company viz. demand, maximum production capacities in a month are treated on utmost priority while doing the production planning. The month wise production schedule is that could bring significant saving for case company. A case study is demonstrated to validate the present methodology. The comparison of existing production schedule and proposed production schedule is demonstrated to show the effectiveness of the present work.

Keywords—linear programming, optimization, production planning, supply-chain management

I.INTRODUCTION

The effective planning in supply-chain management helps in improving the overall performance within the organization. The manufacturing organization should give priority to core activities, i.e. production of the product. The effective production planning can help in reducing the manufacturing cost and inventory cost. A good production planning ensures the proper utilization of men, machine, material, cost, etc. [1].

Generally, Production planning is a multi objective constraint problem and needs the help of experts to optimize the production scheduling [2]. Moreover, the two major uncertainties in the production system are temporary increases in demand and expansion of inventory accordingly [1]. The

objective functions of production planning problems are generally linear in nature, making linear Programming (LP) a suitable optimization approach.

Linear programming is a numerical system used to locate the best possible solution in apportioning restricted assets to accomplish greatest benefit or less cost. More formally, linear programming is a method to achieve the optimal solution for a linear objective function, subject to linear constraints. Despite the fact that the present day administration issues are perpetually changing, most organizations might want to augment benefits or minimize costs with constrained assets [3]. The block diagram of supply chain optimization is presented in figure 1.

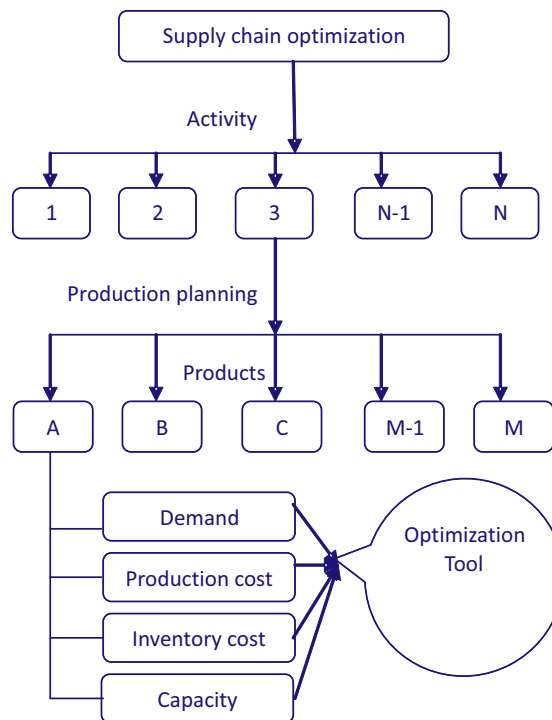


Figure 1. Block diagram of supply chain optimization

This work is carried out to decide the quantity of product A to be manufactured in each month so that there will be a minimal holding cost. The organization of rest of paper is as follows. In Section 2, the literature review is presented. Section 3 presents the need of study and problem definition. The last section concludes the paper as well as guidelines for further research.

II. LITERATURE REVIEW

Researchers have successfully made an effort to optimize supply chain activities. In this section literature relevant to production planning is presented. A framework was presented for evaluation and betterment of production planning in perspective of small manufacturing industry. The proposed framework was validated by presenting 10 case studies of small manufacturing companies in the UK. The barriers and guidelines for the improvement of production planning were presented for managerial implication [4]. An uncertainty modeling was used for effective planning of production. A systematic summary of 87 existing research papers from 1983 to 2004 has been presented, and suggestions were provided for better control of production [5]. An attempt was made to develop a model for production-planning optimization by using Linear Physical Programming (LPP). The main component of the proposed optimization framework was machine yield rates and production time. The case examples of parallel and series production systems having change priorities among the production objectives were demonstrated, and guidelines were provided for optimization application process [2].

An optimization model was presented for producing and soled items under manufacturing constraints. Integer Linear Programming has been used to maximize the objective function i.e. maximizes the profit. Sensitivity analysis was also performed to make the results more realistic [6]. An optimization-based model has been presented for production planning, and physical programming as an effective method to optimize the production planning process within this model's framework. The objective of the proposed model is to minimize cost and manufacturing time, while maximizing production rate. A case example is solved to demonstrate the effectiveness of the present work [7]. [8] developed an integrated framework to optimize production planning within the context of automobile manufacturing environment. The evolutionary algorithm and fuzzy programming was combined to make results more realistic. The results of the proposed model were compared with another method to present the effectiveness of work. The sensitivity analysis was also performed to examine the effects of demand uncertainty, material price, etc. on the supply chain performance. [9] presented the application of nonlinear programming in the planning of steel production. A stepwise lagrangian relaxation approach was performed to improve the approximation error in piecewise linear functions. The problem was decomposed into two parts; the first part was illuminated by LP and second part was solved by the time algorithm. The proposed model was tested on the substantial arrangement of issue examples, and the outcomes demonstrate that the algorithm solutions were bear to the ideal optimal solution. The computational discussion was demonstrated to study the effect of uncertainty in demand on the provided solution. [10] developed a mixed-integer linear program for

production schedule in the process industry. The proposed model provides updates on the actual production each day and the incoming orders. An example of real industry site was demonstrated to show how the scheduling could operate during a month with some production disruptions. [11] presented an integer LP model for both multi-product and multi-time aggregate production plan. The proposed mode works on simultaneously three strategies i.e. reducing the cost, expanding the likelihood of acquiring lower add up to costs and minimizing the danger of getting higher aggregate expenses. The possibilistic environment based particle swarm optimization (PE-PSO) technique was applied to get optimized aggregate production plan. An example was demonstrated to validate the model and also results were compared to other algorithms to show the effectiveness of the proposed model. [12] presented the limitation of the existing model of optimal production planning for petrochemical industries. An attempt has been made to develop a mathematical model for effective production planning, which returns higher profits. The proposed formulation has the ability to consider a large number of levels in production. The existing eight case studies were demonstrated with proposed model and showed an improvement of up to 16.31% in profit.

III. PRESENT WORK

A. Need of study

In this paper, an attempt has been made to optimize the production planning of a manufacturing organization suited in Northern region of India. The company is seeking for effective production planning to meet the demand of market. The company is engaged in manufacturing of small tools, but in this present case study production planning for product A is presented. The reason for selected product A for production planning is the variation in demand of product A. The objective of company is to meet the demand with minimal holding cast. The demands of product A for each month are presented in Table 5.2. The manufacturing cost and holding cost of Product A is Rs 27 and Rs 1 respectively. The company has a capacity to produce maximum 6750 (product A) in a month and it is considered as a constraint in case problem.

TABLE 1
DEMAND CHART FOR PRODUCT A

Month	Demand	Month	Demand
1	6200	7	5000
2	3300	8	3200
3	9000	9	6500
4	8500	10	9000
5	4000	11	8500
6	7200	12	4500

A. FORMULATION OF PROBLEM IN LP

Assumption: The demand of product is not calculated by forecasting. It assumes that demand of the current year will be same as of the previous year.

Formulate this as a linear programming problem by setting up appropriate constraints and objective function.

i) Identify and define the decision variable of the problem Let $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}$ be the number of product manufactured in the month of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 respectively.

ii) Define the objective function

$$\text{Minimize } Z = 27 [x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + x_{11} + x_{12}] + (x_1 - 6200) + (x_1 + x_2 - 9500) + (x_1 + x_2 + x_3 - 18500) + (x_1 + x_2 + x_3 + x_4 - 27000) + (x_1 + x_2 + x_3 + x_4 + x_5 - 31000) + (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 - 38200) + (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 - 43200) + (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 - 46400) + (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 - 52900) + (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} - 61900) + (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + x_{11} - 70400) + (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + x_{11} + x_{12} - 74900)$$

iii) State the constraints to which the objective function should be optimized. The above mentioned objective function is subjected to following constraints.

$$x_1 \geq 6200$$

$$x_1 + x_2 \geq 9500$$

$$x_1 + x_2 + x_3 \geq 18500$$

$$x_1 + x_2 + x_3 + x_4 \geq 27000$$

$$x_1 + x_2 + x_3 + x_4 + x_5 \geq 31000$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 \geq 38200$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 \geq 43200$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 \geq 46400$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 \geq 52900$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} \geq 61900$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + x_{11} \geq 70400$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + x_{11} + x_{12} \geq 74900$$

$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, \leq 6750$$

B. PROBLEM SETUP AND RESULTS

The MATLAB software inbuilt function was used to solve above formulated LPP problems.

Solver: fmincon- constrained non linear minimization

Algorithm: Active set

Derivatives: Approximated by solver

Max iterations: Use default 400

Max function evaluations: Use default $\times 100$ number of variables

Function tolerance: 1e-06

Outcome

1. The minimum objective function value is Rs. 2038750

2. The minimum production is required in the 5th month i.e. 4450.

3. The production of product A is as per maximum capacity i.e. 6750 during month 1, 2, 3, 4, 6, 8, 9, 10, 11.

The comparison between existing and optimized production planning is shown in Appendix A.

II. CONCLUSIONS

The present study demonstrates the overview of the production planning problem. This seeks to minimize the handling cost of product A while respectively all the constraints. An attempt has been made to describe the constraint satisfaction system in terms of production demand and production capacity. The result showed that the optimum production schedule can reduce the handling cost of Rs 16450. As a conclusion, we believe that the achieved results are utilized the time and effort, to balance the production schedule more contented and effective. The use of MATLAB avoids heavy mathematical calculations and the possibility of the blunder in statistical calculation. The similar methodology can be adopted to optimize other activities such as

REFERENCES

1. L. Huang, J. Q., Hu and P. Vakili, "Optimal control of a failure prone manufacturing system with the possibility of temporary increase in production capacity", *Lecture Notes in Control and Information Sciences 21-Recent Advances in Control and Optimization of Manufacturing Systems*, Springer-Verlag, pp. 31-60, 1996
2. A. Maria, C. Mattson, A. I. Yahaya and A. Messac, "Linear physical programming for production planning optimization, *Engineering Optimization*", vol. 35, no. 1, pp. 19-37, 2003.
3. B. S. Kumar, G. Nagalakshmi and S. Kumaraguru, "A Shift Sequence for Nurse Scheduling Using Linear Programming Problem", *IOSR Journal of Nursing and Health Science*, vol. 3, no. 6, pp. 24-28, 2014.
4. B. McGarrie, "Case study: production planning and control-selection, improvement and implementation," *Logistics Information Management*, Vol. 11, no. 1, pp. 44-52, 1998.
5. J. Mula, R. Poler, J.P. Garc'a-Sabater and F.C. Lario, "Models for production planning under uncertainty: A review", *International Journal of Production Economics*, vol. 103, pp. 271-285, 2006.
6. T. Imam and F. Hassan, "Linear Programming and Sensitivity Analysis in Production Planning", *International Journal of Computer Science and Network Security*, vol. 9, no. 2, pp. 456-465, February 2009.
7. A. Messac, W. M. Batayneh, and A. I. Yahaya, "Production planning optimization with Physical Programming", *Engineering Optimization*, vol. 34, no. 4, pp. 323-340, 2002.
8. G. Zhang, J. Shang, and W. Li, "Collaborative production planning of supply chain under price and demand uncertainty," *European Journal of Operational Research*, vol. 215, no. 3, pp. 590-603, 2011.
9. L. Tang, P. Che, and J. Liu, "A stochastic production

planning problem with nonlinear Cost," *Computers & Operations Research*, vol. 39, no. 9, pp. 1977-1987, 2012.

10. A. Lindholm, P. Giselsson, N.-H. Quttineh, H. Lidestam, C. Johnsson and K. Forsman, "Production scheduling in the process industry," *22nd International Conference on Production Research*, 2013.
11. R. K. Chakraborty, Md. A.A. Hasin, R.A. Sarker, and D. I.

L. Essam, "A possibilistic environment based particle swarm optimization for aggregate production planning," *Computers & Industrial Engineering*, vol. 88, pp. 366-377, 2015

12. R. Kadambur and P. Kotecha, "Optimal production planning in a petrochemical industry using multiple levels," *Computers & Industrial Engineering*, vol. 100, pp. 133-143, 2016.

Annexure A: Comparison between existing and optimized production planning

Month	Demand	Existing Planning		Optimized planning	
		Production plan	Inventory	Optimize Production plan	Inventory
1	6200	6750	550	6750	550
2	3300	6750	4000	6750	4000
3	9000	6750	1750	6750	1750
4	8500	6750	0	6750	0
5	4000	6200	2200	4450	450
6	7200	6200	1200	6750	0
7	5000	6200	2400	5200	200
8	3200	6200	5400	6750	3750
9	6500	6200	5100	6750	4000
10	9000	6200	2300	6750	1750
11	8500	6200	0	6750	0
12	4500	4500	0	4500	0
Holding Cost (Rs)			24900		16450

AUTHORS

Harwinder Singh, Professor, Department of Mechanical Engineering, Guru Nanak Dev Engineering College, Ludhiana, Punjab, India

Email : harwin75@rediffmail.com,

Raman Kumar Assistant Professor, Department of Mechanical Engineering, Chandigarh University, Gharuan, India

Email : ramankakkar@gmail.com