

Determination of Optimal Production Number by Considering the Use of Raw Materials Using Goal Programming Approach

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ABSTRACT

The company produces PVC pipes in Medan city is experiencing problems in the form of a higher number of requests compared to the production number. This is because the company does not have a good production plan which is the results in not meeting consumer demand. For this reason, a good and integrated production planning is needed by using the goal programming method. Production planning carried out with goal programming aims to maximize company profits. The results shows that by using the goal programming method, the optimal production number was obtained at each type of 2-inch ECO JIS D pipe products of 42851 units, 3-inch ECO JIS D pipe products of 54445 units and 4 inches of ECO JIS D pipe products 24480 units. In addition, by using this method the company profits about Rp. 446,620,100 is greater than the actual method applied by the company.

Keywords: PVC, raw materials, programming

1. INTRODUCTION

The increasing level of competition between companies is strictly increasing in attracting and satisfying consumers, companies must increase efficiency, produce quality products, and the ability to deliver products at the right time with the right amount. The company must also have a good and proper production plan, which is the determination of the product type, quantity and production schedule that suitable to the consumers need. The number and production schedule has been determined achieved if supported by sufficient available capacity. With the production plan, the company allocate resources appropriately, reduce production costs and save costs, and capable to deliver products at the right time. Production planning is one of the most important functions in the process of production and operation management [1]. Production planning is an activity deals with production determination, the number of production products, when the product is produced, and the number of workers needed to get the product determination[2]. In production planning, managers of manufacturing companies need to make specific decisions on specific aggregate levels of production, inventory and work force to be produced to meet possible demands. Such decisions are traditionally interpreted as finding a best combination of production, inventory and minimum work force result to costs [3].

The company in PVC pipe production experiencing problems several times, namely the usage number is far more than the production number in a certain period and consumer demand is not achive by the company. This is because the company does not have a good production plan to anticipate fluctuating consumer demand

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causing these problems to happen. For this reason, a good production plan is needed for the company to anticipate this. Production planning is carried out with several methods, one of them which is the goal programming method. The goal programming technique was originally developed by Charnes and Copper [4]. Goal programming (GP), which is an extension of LP, is commonly applied to deal with multi-objective problems [5]. The basic approach of GP is to establish a specific numeric value (aspiration level) for each objective, formulating an objective function at each objective, and then find a solution to minimize the definition of these objectives. [6].

Research to handle production planning problems has been done before. The study was conducted by Pupy Ajiningtya, et al. in 2013 at the Sugar Factory in East Java. Based on these studies, obtained results that not all of company targets are met for product sales targets, sales profits are met, minimum production costs are met, minimum raw material usage and maximum machine working hours are met [7]. Muchlisson Anis [8] also conducted research using goal programming, this shows that the product combination of goal optimization goals was more profitable than what the company had done so far. The advantage of companies with goal programming solutions is Rp. 528,221,207,000 while the profits of the company if making products based on request demand is Rp. 460,368,641,000. However, not much research has been done to handle the problem of production planning with goal programming in pipecompanies, especially in Medan city. This study aims to determine the optimal prudction number of pipe by maximizing the profits obtained by the company.

2. METHODOLOGY

The study was conducted in one of the industries in the Medan city which is produces pipes in the form of pipes. The object studied in this study is a pipe with PVC ECO JIS D type products 2 inches, 3 inches, and 4 inches. Research begins with observations to observe and see the condition of the industry. After observation, the topic and research objectives are determined according to the conditions on the production floor. Then data collection is needed to handle production planning problems that happen. The data collected in the form of the number of product demand, cost of goods manufactured, product processing time, and the other data. The collected data is then processed using the goal programming method.

The stages of the work process in the problems handling of production planning begin with forecasting demand. Forecasting is carried out with the aim to estimate pipe production volume in the next period. The forecasting calculation is done by time series method and considering error estimation. The next stage is to do production volume planning using the goal programming method determinationis. Goal programming which was originally presented as one of the most important methods for solving multi-objective programming problems [4].

This method begins with the decision variable. The decision variable in question is the problem variables affects the value of the goal to be achieved. Decision variables must be determined first before formulating the objective function and constraints. After the decision decision is obtained, then the objective function (target) is determined and the constraints for the value of the goal to be achieved.

After that, the achievement function is determined by combining the decision variables with the objective function and constraints. The achievement function is done by using LINDO software to determine the optimal production number. With this software, an optimal amount of production will be obtained at each type of pipe product. Then the calculation is done to see the profits obtained by the company by considering the profits obtained by the company with the method applied by the company before. The results of this calculation will be the output in the feasibility determination of the goal programming method.

3. RESULT AND DISCUSSION

3.1 PRODUCT DEMAND FORECASTING

Forecasting carried out aims to predict the production number in the next period using the time series method. Forecasting results are selected based on the smallest error estimation. The forecasting results obtained by the time series method considers error estimation can be seen in Figure 1.

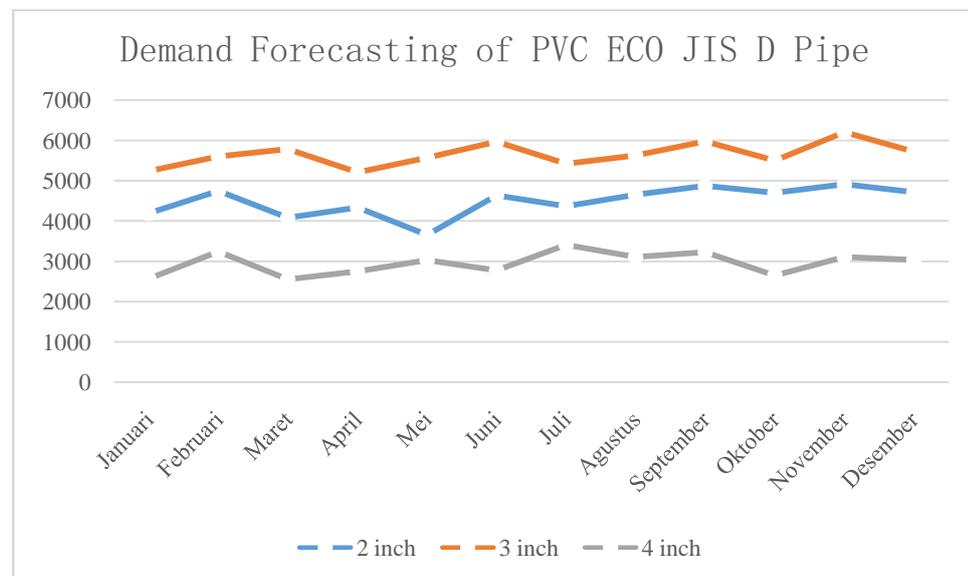


FIGURE 1. Result of PVC ECO JIS Pipe Products D Product Demand

Based on the graph above, it can be seen that product demand at each type of pipe product fluctuated every period. The largest number of demands for 2 inch PVC ECO JIS D pipe products is 4914 units and the smallest demand is 3655 units. For 3 inch PVC ECO JIS D pipe products, the largest and smallest number of demands are 6208 units and 5208 units. Besides, for 4 inch PVC ECO JIS D pipe products, the largest and smallest number of demands are 3408 units and 2552 units respectively. These results indicates that there is a fluctuating product demand at each order period and production planning is needed and all demands at each period can be achieved.

3.2 PRODUCTION PLANNING WITH GOAL PROGRAMMING METHOD

3.2.1 DECISION VARIABLE

Decision variables are problem variables affects the value of the objectives to be achieved. The invention of the decision variable done first before formulating the objective function and its constraints. The decision variable in production planning in this pipe industry is X1 is the total production of ECO JIS pipe D 2 inches per month (unit); X2 is the number of ECO JIS pipe production D 3 inches per month (units); X3 is the total production of ECO JIS D pipe 4 inches per month (unit).

3.2.2 OBJECTIVE FUNCTIONS AND CONSTRAINTS

The objectives to be achieved in this study is to maximize production volume and profits. To maximize production volume, the forecasting production result of ECO JIS D 2 inches, 3 inches, and 4 inches are used with a safety stock set by the company about 2 percent. The goal programming model obtained at each type product in January is as follows:

$$X_{1\text{January}} + 0,02X_{1\text{January}} + d_1^- - d_1^+ = 3807 \quad (1)$$

$$X_{2\text{January}} + 0,02X_{2\text{January}} + d_{13}^- - d_{13}^+ = 4850 \quad (2)$$

$$X_{3\text{January}} + 0,02X_{3\text{January}} + d_{25}^- - d_{25}^+ = 2176 \quad (3)$$

The constraint function is carried out every month for all types of products because the demand products are different every month.

Objectives for the availability constraints and availability of raw materials are carried out by considering the relationship between usage and availability of raw materials and the number of production product. The goal programming model with the constraint function in January as follows:

$$0,37 X_{1\text{Januari}} + 0,36X_{2\text{Januari}} + 0,50X_{3\text{Januari}} + d_{85}^- - d_{85}^+ = 31500 \quad (4)$$

3.2.3 FORMULATION OF ACHIEVEMENT FUNCTIONS

Formulating achievement functions is done by combining decision variables with constraints and objectives. Based on the goals to be achieved by the company are

production volume and profits, then the formulation of the achievement of Goal Programming problems for planning in January are:

$$\text{Min DB1} + \text{DB13} + \text{DB25} + \text{DB37} + \text{DB49} + \text{DB61} + \text{DB73} + \text{DB85} + \text{DB86} + \text{DB87} + \text{DB88}$$

SUBJECT TO

$$X1 + 0.02 X1 + \text{DB1} - \text{DA1} = 3807$$

$$X2 + 0.02 X2 + \text{DB13} - \text{DA13} = 4850$$

$$X3 + 0.02 X3 + \text{DB25} - \text{DA25} = 2176$$

$$0,37X1 + 0,36X2 + 0,50X3 + \text{DB85} - \text{DA85} = 31500$$

END

By using the above formulation, calculation of the objective function and constraint function is done by using LINDO (Linear Interactive Discrete Optimizer) software to determine the optimal production number t each product. Recapitulation of production planning of 12 months from the completion of the Goal Programming achievement function using the LINDO software program can be seen in Table 1.

TABLE 1.
Recapitulation of Production Planning in 12 Month Using Goals Programming

Period	Number of ECO JIS Pipe Production with Goal Programming			Number of Actual Production of ECO JIS D Pipes from the Company		
	2 inch	3 inch	4 inch	2 inch	3 inch	4 inch
January	3732	4754	2133	3169	3813	1896
February	3773	4803	2155	3025	3655	1812
March	3813	4851	2178	2942	3493	1754
April	3857	4900	2202	3108	3775	1792
May	3892	4949	2224	2835	3524	2054
June	3933	4997	2247	3066	3528	1802
July	3973	5045	2269	3175	3611	1828
August	4013	5094	2293	2947	3386	1628
September	4053	5143	2315	3073	3741	1654
October	4093	5191	2338	2804	3429	1763
November	4133	5241	2363	2962	3652	1764
December	4173	5289	2385	3019	3529	1871

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Total	47438	60257	27102	36125	43136	21618
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Based on the table above it is known that the production number produced by using goal programming is greater than the actual method applied by the company and profits obtained by the company increase. Recapitulation of the use of raw materials of 12 months from the completion of the Goal Programming achievement function by using the LINDO software program can be seen in Table 2.

TABLE 2.
Recapitulation of the Use of Raw Materials in 12 months Using a Goal Programming

Month	Usage Based on Goal Programming				Usage Based on Actual Conditions			
	Resin	Calcium Carbonate	BS	Titanium	Resin	Calcium Carbonate	BS	Titanium
January	4148,09	1842,05	4320,78	366,1	31500	15750	31500	1050
February	4202,15	1861,39	4366,06	369,93	31500	15750	31500	1050
March	4245,85	1880,67	4411,27	373,75	31500	15750	31500	1050
April	4292,01	1901,07	4459,02	377,77	31500	15750	31500	1050
May	4333,63	1919,41	4502,15	381,43	31500	15750	31500	1050
June	4377,72	1938,89	4547,79	385,29	31500	15750	31500	1050
July	4420,9	1958,03	4592,64	389,08	31500	15750	31500	1050
August	4465,13	1977,44	4638,22	392,93	31500	15750	31500	1050
September	4508,68	1996,77	4683,51	396,76	31500	15750	31500	1050
October	4552,38	2016,05	4728,73	400,59	31500	15750	31500	1050
November	4596,98	2016,05	4728,73	400,59	31500	15750	31500	1050
December	4640,16	2035,66	4774,76	404,48	31500	15750	31500	1050
Total	52783,68	23343,48	54753,66	4638,7	378000	189000	378000	12600

The use of raw materials using goal programming is smaller compared than to the company inventory. These results indicates that the company needs to reconsider the inventory set by the company and the material can be used optimally.

4. CONCLUSION

Goal programming is used to determine the optimal production number and maximize the use of raw materials. By using this method, the production of 2-inch ECO JIS D pipe products of 47,438 units, 3-inch ECO JIS D pipe products of 60,257 units, and for 4-inch ECO JIS D pipe products of 27,102 units. The number of raw material usage for ECO JIS D pipe products is resin of 52783.68 kg, calcium carbonate of 23343.48 kg, BS of 54753.66, and titanium of 4638.7 kg, with these results obtained by using this method is better compared than to the actual method applied by the company.

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REFERENCES

- [1] M F Rad, H. Shirouyehzad, 2014 *Journal of Data Envelopment Analysis and Decision Science*, 1-13
- [2] S. Sinulingga, 2013 *Metode Penelitian* (Medan: USU Press)
- [3] Y. Shi, 2001 *Multiple Criteria and Multiple Constraint Levels Linear Programming* (Publishing Co. Pte. Ltd)
- [4] A. Charnes and W. W. Cooper, 1961 *Management Models and Industrial Applications of Linear Programming* (New York: Wiley)
- [5] A. K. Rifai, 1994 *International Journal of Operations and Production Management*, **16** (1)
- [6] A. D. Adeyeye and O. E. Charles Owaba 2008 *South African Journal of Industrial Engineering*, **19** (2) 197-209
- [7] E W. Anggraeni, R. A. Vinarti, R. Tyasnurita, and J. Permatasari, 2015 *Journal of Advanced Management Science*, **3** (4)
- [8] S. Anwar and L. Afrizalmi, 2015 *ICOMSET*, 90-95
- [9] E. C. K Chandra, 2015 *International Journal of Surface Mining and Reclamation*, **4** 125-129