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Goal Programming Model to Optimize the Amount of Gauze Production

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ABSTRACT

PT KHW is a company engaged in the manufacture of cotton and gauze for health and cosmetic purposes. The gauze products produced by the company sometimes exceed the number of consumer demands and sometimes there is a shortage of products. Therefore, good production planning in order to meet consumer demand with the right amount and the right time is needed so the increased profits are obtained. This study aims to determine the optimal amount of production, determine the profits obtained by the company and determine the production costs that must be incurred by the company. This study uses the goal programming method to optimize the amount of production by determining the decision variables, constraint functions and target functions. The goal functions are arranged based on the priority level desired by the company. The goal priorities considered include the goal of maximizing the amount of production, maximizing product sales profits, minimizing production costs, minimizing the use of raw materials, maximizing production time, and minimizing overtime.

Key Words: Goal Programming, Gauze, Goal Priorities, Production Planning.

1. INTRODUCTION

PT Kasa Husada Wira (PT KHW), located in Surabaya, Jawa Timur, Indonesia, is a company engaged in the manufacture of cotton and gauze for health and cosmetic purposes. This company has been trusted by consumers to be a company in the health sector with the best quality that meets Indonesian Pharmacopoeia standards. It produces two types of gauze, namely sterile hydrophilic gauze 16x16 and premium sterile 16/16 gauze. The company sometimes produces the gauze exceedingly higher than the demand from the consumer and sometimes there is a shortage product. An optimal production planning is needed by the company to solve this issue. Companies must be able to manage the limited resources they have accurately such as machines, working hours, labor, raw materials and warehouse capacity well. Good production planning must concentrate on three aspects, namely consumers, production and manufacturing processes [1].

Every company has the possibility to be faced with the problem of optimizing some goals in the production process. One of these goals will affect the other goals. The process of optimizing one goal will affect other goals so it can cause losses. Therefore, we need a mathematical model that is able to make the optimal solution. One of the models that can be used in production planning for several purposes is goal programming. The function of goal programming is to adjust the company goals accurately and precisely with the resources in production planning. This method requires input from existing resources in the company to obtain the desired decisions and results. Some of the inputs needed include the number of product requests, production results, production costs, product selling prices, availability and use of raw materials, as well as the number of working days.

Goal programming is a mathematical model used to create solutions and analyze problems that require multiple goals to obtain an optimal solution [2]. This method provides optimal answers so it can meet the goals of the company [3]. Several researchers have used Goal programming to plan production optimally and accurately such as [4,5,6,7,8]. The goal programming method has been widely applied in various fields including Nurse's scheduling [9], supplier [10] and green supplier selection [11], sustainable supplier management [12], disaster rescue unit allocation [13]. renewable energy [14], assignment optimization [15], and transportation problems [16,17].

2. RESEARCH METHODS

2.1 Development Goal Programming Model

The goal programming method in this study is used to determine the optimal amount of gauze production. The development of this goal programming model includes the formulation of notation, constraint functions and goal functions.

- Notations

Model notations used in this goal programming model are defined as follows:

i = product index, $i \in N$
t = period index, $t \in T$
j = raw material index, $j \in R$
x_{it} = number of product *i* produced in period *t*
D_{it} = demand of product *i* for period *t*
B_{ij} = amount of raw material *j* used by product
BT_{jt} = quantity availability of raw material *j* in period *t*
J_i = processing time of product *i*
JK_t = available production time in period *t*
JL_t = available overtime in period *t*
EP_t = expected profit in period t
P_i = profit of product *i*

- Constraint Functions

The constraint functions of the goal programming model include production volume constraints, raw material availability constraints and production time availability constraints.

a. Production volume constraint

$$x_{it} \geq D_{it}, \forall i \in N, \ \forall t \in \mathrm{T}, \text{---------} (1$$

b. Raw material availability constraint

$$\sum_i \sum_j B_{ij}\, x_{it} \leq BT_{jt}, \forall t \in T, \text{---------} (2)$$

c. Production time availability constraint

$$\sum_i J_i\, x_{it} \leq JK_t, \forall t \in T \text{---------} (3)$$

- Goal Functions

The goal functions are arranged based on the priority level wanted by the company. The goal functions considered include the goal of maximizing the amount of production, maximizing product sales profits, minimizing production costs, minimizing the use of raw materials, maximizing production time, and minimizing overtime.

a. The goal of maximizing the amount of production
The constraint function for maximizing the production quantity is as follows.

$$x_{it} \geq D_{it}, \forall i \in N, \forall t \in T, \ \text{---------} (4)$$

Goal programming :

$$x_{it} + d_{it}^{-} - d_{it}^{+} = D_{it}, \ \forall i \in N, \forall t \in T \ \text{---------} (5)$$

The company wants to maximize the volume of production for each type of product, so the negative deviation is attempted to be zero so there is no shortage of production. However, the increase in the amount of production is not too high, both negative and positive deviations are minimized. The achievement function for this goal is as follows.

$$Min\ Z = \sum_i \sum_t (d_{it}^{-} - d_{it}^{+}), \ \text{---------} (6)$$

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b. The goal of maximizing the product sales profits
The constraint function for maximizing the product sale profit is as follows.

$$\sum_i P_i\, x_{it} \geq EP_t, \quad \forall t \in T \text{ --------- (7)}$$

Goal programming:

$$\sum_i P_i\, x_{it} + e_t^- - e_t^+ = EP_t, \forall t \in T \text{ --------- (8)}$$

The company's goal is to maximize product sales profits. Therefore, the negative deviation is minimized so the profit that is below the expected profit can be minimized. The achievement function for this goal is as follows.

$$Min\ Z = \sum_t e_t^- \text{ --------- (9)}$$

c. The goal of minimizing production costs
The constraint function for minimizing production costs is as follows.

$$\sum_i C_i\, x_{it} \geq PC_t, \quad \forall t \in T \text{ --------- (10)}$$

Goal programming:

$$\sum_i C_i\, x_{it} + f_t^- - f_t^+ = PC_t, \forall t \in T \text{ --------- (11)}$$

The company's goal is to minimize the production costs of each type of product. Therefore, the positive deviation should be minimized. The achievement function for this goal is as follows:

$$Min\ Z = \sum_t f_t^+ \text{ --------- (12)}$$

d. The goal of minimizing the use of raw materials
The constraint function for minimizing the use of raw materials is as follows.

$$\sum_i \sum_j B_{ij}\, x_{it} \leq BT_{jt}, \forall t \in T \text{ --------- (13)}$$

Goal programming:

$$\sum_i \sum_j B_{ij}\, x_{it} + g_t^- - g_t^+ = BT_{jt}, \forall t \in T \text{ --------- (14)}$$

The company's goal is to minimize the amount of use of raw materials, so the positive deviation must be minimized so that the excess use of raw materials is attempted to be zero. The achievement function for this goal is as follows.

$$Min\ Z = \sum_t g_t^+ \text{ --------- (15)}$$

e. The goal of maximizing production time
The constraint function for maximizing production time is as follows.

$$\sum_i J_i\, x_{it} \leq JK_t, \forall t \in T \text{ --------- (16)}$$

Goal programming:

$$\sum_i J_i\, x_{it} + h_t^- - h_t^+ = JK_t, \forall t \in T \text{ --------- (17)}$$

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The company's goal is to maximize the use of machine working hours. Therefore, the negative deviation must be minimized or to be zero so the working hours are proper for the production process. The achievement function for this goal is as follows:

$$Min\ Z = \sum_t h_t^- \text{ --------- (18)}$$

f. The goal of minimizing overtime

The company has a policy that if product demand exceeds the production target, additional working hours or overtime will be carried out. The target of minimizing overtime hours can be formulated as follows.

$$k_t^+ \leq JL_t, \forall t \in T \text{ --------- (19)}$$

The achievement function for this goal is as follows:

$$Min\ Z = \sum_t k_t^+ \text{ --------- (20)}$$

- Goal Programming Model

The complete goal programming model is as follows.

$$Min\ Z = P_1 \sum_i \sum_t (d_{it}^- - d_{it}^+) + P_2 \sum_t e_t^- + P_3 \sum_t f_t^+ + P_4 \sum_t g_t^+ + P_5 \sum_t h_t^- + P_6 \sum_t k_t^+$$

Subject to:

$$x_{it} + d_{it}^- - d_{it}^+ = D_{it}, \quad \forall i \in N, \qquad \forall t \in T$$

$$\sum_i P_i\, x_{it} + e_t^- - e_t^+ = EP_t, \forall t \in T$$

$$\sum_i C_i\, x_{it} + f_t^- - f_t^+ = PC_t, \forall t \in T$$

$$\sum_i \sum_j B_{ij}\, x_{it} + g_t^- - g_t^+ = BT_{jt}, \forall t \in T$$

$$\sum_i J_i\, x_{it} + h_t^- - h_t^+ = JK_t, \forall t \in T$$

$$k_t^+ \leq JL_t, \forall t \in T$$

$$x_{it}, d_{it}^-, d_{it}^+, e_t^-, e_t^+, f_t^-, f_t^+, g_t^-, g_t^+, h_t^-, h_t^+, k_t^+ \geq 0$$

2.2 Mathematical Model Verification

Verification of the goal programming model formed is conducted by comparing the unit dimensions of the left and right sides of the equation. The verification results show that the model has the same unit dimensions between the left and right sides. The process of finding the optimal solution for the goal programming model is carried out using the LINGO software.

.3. RESULT AND DISCUSSION

The goal programming model is used to determine the optimal amount of production, find out the profits obtained by the company and find out the production costs that must be incurred by the company for the next 2 periods.

3.1 Data

The company has 2 gauze products, namely Hydrophilic Sterile Gauze 16x16 KH (product 1) and Premium Sterile 16/16 Gauze (product 2). The main raw materials for making these gauze products are 40s and 30s yarns. Product 1 requires 60% of 40s yarn and 40% of 30s yarn. Product 2 requires 20% of 40s yarn and 15% of 30s yarn. Each period there are 160,000 meters of 40s yarn and 100,000 meters of 30s yarn. The maximum allowed overtime is 32 hours in each period. The expected profit of period 1 is Rp.

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805,550,948 and period 2 is Rp. 809,618.417. The available production time in period 1 is 176 hours and period 2 is 152 hours. Data related demand per period, the profit of each product, the production costs are in Table 1.

Table1. Data Demand, Profit and Production Cost

Product	Demand (Dose)		Production Cost (Rupiah)	Profit (Rupiah)
	Period 1	Period 2		
1	200,863	210,630	3,819	5,729
2	18,440	18,988	2,083	8,333

3.2 Production Planning Summary

The output obtained from the LINGO software is presented into a Table 2 and Table 3 for production planning for period 1 and 2.

Table2. Production Planning for Period 1

Parameter	Solution
Product 1	200,875 doses
Product 2	18,440 doses
Profit	Rp. 805,594,862
Production cost	Rp. 1,304,472,000
The 40 s yarn used	124,212 meters
The 30 s yarn used	83,116 meters
Production time used	200 hours

Based on the results obtained in table II, it can be seen that the company produces products 1 and 2 according to consumer demand. The company produce the product 1 as big as 200,875 doses. This production value exceeds the number of consumer demands by 200,863 doses. This excess value is only equal to the product of 12 doses. The profit earned by the company is Rp. 805,594,862 with production costs of Rp 1,304,472,000. The 40s yarn used is 124,212 meters so the remaining 40s yarn is 35,788 meters. The 30s yarn used is 83,116 meters so the remaining 30s yarn is 16,884 meters. To produce these two products, the company must do overtime as much as 24 hours.

Based on the results of lingo that all goals in the goal programming model are achieved. The target to meet demand is obtained by products 1 and 2. In addition, the target of minimizing the shortage of production quantities is obtained by a negative zero deviation value. This shows that the target is achieved. However, there was an overproduction of product 1 by 12 doses. The goal of maximizing product sales profits and the target of minimizing profits below the target is achieved because the positive and negative deviation values are zero. The goal of minimizing production costs is achieved where the positive deviation value is zero. The cost to be incurred is Rp. 1,304,472,000. The goal of minimizing the use of raw materials is achieved in both types of raw materials used where the positive deviation value for 40s yarn and 30s yarn is zero. The goal of maximizing production time is achieved because there is no deviation from the available production time where the negative deviation value is zero. However, there was an excess of 24 hours of production time. The target of minimizing overtime hours is achieved because there is no deviation from the maximum capacity of overtime hours where the positive deviation value is zero.

Table3. Production Planning for Period 2

Parameter	Solution
Product 1	201,641 doses
Product 2	18,988 doses
Profit	Rp. 809,662,862
Production cost	Rp. 1,313,427,000
The 40 s yarn used	124,783 meters
The 30 s yarn used	83,505 meters
Production time used	201 hours

Based on the results obtained in table III, the company produces products 1 and 2 according to consumer demand. Product 1 produced at 201,641doses and product 2 produced at 18,988 doses. This excess value of product 2 is only 11 doses. The profit

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earned by the company is Rp. 809,662,727 with production costs of Rp 1,313,427,000. The 40s yarn used is 124,783 meters so the remaining 40s yarn is 35,217 meters. The 30s yarn used is 83,505 meters so that the remaining 30s yarn is 16,405 meters. To produce these two products, the company must do overtime as much as 25 hours.

The target to meet demand is obtained by products 1 and 2. In addition, the target of minimizing the shortage of production quantities is obtained by a negative zero deviation value. This shows that the target is achieved. However, there was an overproduction of product 1 by 11 doses. The goal of maximizing product sales profits and the target of minimizing profits below the target is achieved because the positive and negative deviation values are zero. The goal of minimizing production costs is achieved where the positive deviation value is zero. The cost to be incurred is Rp. 1,313,427,000. The goal of minimizing the use of raw materials is achieved in both types of raw materials used where the positive deviation value for 40s yarn and 30s yarn is zero. The goal of maximizing production time is achieved because there is no deviation from the available production time where the negative deviation value is zero

4. CONCLUSIONS

This study aims to determine the optimal amount of production, determine the profits obtained by the company and determine the production costs that must be incurred by the company. Based on the result analysis and discussion, it can be concluded that the goal programming models can be applied to PT KHW. Furthermore, by using goal programming model, PT KHW can meet all of the company goals precisely.

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