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A Study of Mathematical Problems as Control Agents in the Industrial Sector

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ABSTRACT

PD Utama Jaya Plasindo, a company specializing in plastic pellet processing, faces several production challenges, such as fluctuating demand, raw material shortages, machinery downtime, and labor management. To address these issues and improve production planning, the company uses MATLAB's linprog tool, which is designed for Linear Programming (LP) and aims to maximize profits. The company's profit is calculated using the formula: Profit = 37A + 46B + 38C + 46D. This calculation takes into account seven constraints related to raw materials, machinery usage, labor hours, and product demand. With this method, PD Utama Jaya Plasindo earns a daily profit of Rp. 837,600 from its plastic buckle products, totaling Rp. 16,752,000 over 20 working days in a month. These profit figures, based on clear objectives and constraints, help ensure that production goals are met and facilitate the monitoring and optimization of production capacity. By leveraging MATLAB's linprog, the company can better manage demand fluctuations and optimize the use of raw materials, machinery, and labor.

Keywords: linear programming, plastic buckles, MATLAB linprog

INTRODUCTION

Every year, approximately 100 million tons of synthetic plastic packaging are produced worldwide for various industrial (Fafurida et al., 2016) sectors, resulting in a comparable volume of plastic waste(Jambeck et al., 2015). In Indonesia alone, the annual demand for plastic reaches 2.3 million tons (Alfarisa et al., 2015). However, the main concern lies in the non-degradable nature of much of the plastic currently circulating in society, posing a serious threat to the environment. With the continuous expansion of the food industry, the demand for plastic (Puspita et al., 2024) as a packaging material indirectly rises. However, if this trend persists without change, it will have detrimental effects on the surrounding environment. Therefore, a more cautious approach is required to manage plastic usage, which includes adopting environmentally friendly technologies and practices in the production and packaging processes. This approach will help reduce the negative impact on the environment while still meeting the needs of both industry and consumers.

PD Utama Jaya Plasindo is a trading company engaged in plastic pellet processing. The company has a factory where plastic (Burhanuddin et al., 2018) pellet processing activities are carried out. However, PD Utama Jaya Plasindo also faces several issues in production planning. Fluctuations in demand for goods, which vary from one period to another, result in production shortages or surpluses. At times, a surge in demand can leave the company short on production items, making it difficult to meet demand effectively. This uncertainty can affect the company's profitability and sometimes fall short of the owner's expectations. Conversely, a decrease in demand can lead to surplus production items and unwanted stockpiling. Hence, it's crucial for the company to enhance its production planning to ensure smoother alignment with market demand. This planning process entails making optimal decisions based on available resources to fulfill the demand for manufactured products. Consequently, the company can anticipate fluctuations in market demand and optimize resource allocation to ensure sufficient product availability in line with customer needs.

Based on observations at PD Utama Jaya Plasindo, a manufacturing company known for producing plastic buckles under the brand "Eagle's," it's evident that the company faces challenges in determining the optimal production quantity given the available resources. This difficulty results in struggles to meet market demand and maximize profitability. Consequently, a study was undertaken to ascertain the ideal production quantity for various types of plastic buckles to enhance the company's profitability. With the continuous evolution of technology, this issue can be tackled by modeling several relevant variables within a linear programming (Indah & Sari, 2020) framework. By adopting this method, an application can be developed to aid production planning and control at PD Utama Jaya Plasindo. Such an application will help optimize resource allocation and streamline production according to market demand, thereby boosting the company's profitability and solidifying its competitive stance in the industry. Based on observations at PD Utama Jaya Plasindo, it's evident that the company struggles to determine the ideal production quantity for various plastic buckle types, considering the available production capacity. Currently, the company often relies on past production experiences, leading to occasional overproduction or underproduction. This inconsistency can disrupt the company's ability to meet consumer demand consistently and achieve maximum profitability. For instance, if production falls short of demand, customers might be dissatisfied, risking loss of clientele. The study addresses several key issues, including the challenges the company faces in optimizing production (Sriwidadi & Agustina, 2013) for different plastic buckle variations to maximize profit (Setiarini et al., 2023) potential for each variation. Through this research, the aim is to tackle these challenges effectively. The insights gained are expected to aid the company in making informed decisions about resource allocation, such as machinery, labor, funds, time, and raw materials. This strategic allocation will enable the company to produce efficiently, satisfying consumer demands consistently. Ultimately, this approach is anticipated to boost consumer satisfaction and contribute to the overall success of the company.

MATERIAL AND METHOD

Plastic Pellets

In general, plastics are categorized into two main groups: thermoplastics and thermosets.

Thermoplastics: These plastics become smooth and flexible when heated, allowing them to be easily molded to meet specific needs. Because of this, thermoplastics are widely used in everyday products such as bottles, food containers, and various packaging materials. Common examples include Polyethylene (PE) and Polyvinyl Chloride (PVC).

Thermosets: In contrast to thermoplastics, thermosets become hard and do not soften when heated. This makes them ideal for applications requiring high strength and durability. They are often used in large industries and for spacecraft components because

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they can withstand extreme conditions. Examples of thermosets include Polypropylene (PP) and Polyamide (PA).

In addition to their thermal properties, plastics are also classified commercially by their constituent materials, each with specific characteristics and uses. Some well-known types include:

- **Polyethylene (PE)**: Used in plastic bags, bottles, and toys.
- **Polyvinyl Chloride (PVC)**: Commonly used for pipes, cables, and flooring.
- **Polypropylene (PP)**: Used in household appliances, textiles, and automotive components.
- **Polymethyl Methacrylate (PMMA)**: Also known as acrylic, used as a glass substitute.
- **Acrylonitrile Butadiene Styrene (ABS)**: Used for products requiring high strength and durability, such as electronic casings and toys.
- **Polyamide (PA)**: Also known as nylon, used in textiles and automotive industries.
- **Polyester**: Used in hardening and sealing liquids.
- **Polyethylene Terephthalate (PET)**: Used for beverage bottles and food packaging.

Each type of plastic is chosen based on its unique characteristics that suit specific applications, providing flexibility and efficiency across various industries. By understanding the properties and uses of each type, industries can optimally utilize these materials for diverse purposes.

The research conducted is a descriptive study. Descriptive studies are often used by organizations to understand and explain the characteristics of their employees. For example, an organization might want to know the distribution of age, education level, employment status, and length of service among its employees. This information is crucial for understanding workforce demographics and designing policies or programs that meet employee needs. Descriptive studies are also commonly used to understand the characteristics of organizations that follow certain practices. For instance, a study might examine how companies in a particular industry adopt new technologies or implement environmentally friendly policies. The main objective of descriptive studies is to give researchers a detailed account of relevant aspects of the phenomenon of interest from the perspectives of individuals, organizations, industry orientations, and others. This research provides rich and valuable information for further analysis and better decision-making in the future.

In its implementation, this research (Sugiono et al., 2020) uses the survey method, targeting a large population but studying data from a sample taken from that population. This method allows researchers to gather relevant information from a group of respondents' representatives of the broader population, ensuring that the findings can be generalized and provide an accurate depiction of the characteristics and phenomena being studied. The unit of analysis in this research is PD Utama Jaya Plasindo, specifically the production department. Focusing on this department aims to gain a deeper understanding of its operational aspects, productivity, and work efficiency. By examining this unit, the researcher can identify key factors influencing production performance and offer recommendations for further improvement. The time horizon for this research is cross-sectional, or a one-shot study. In a one-shot study, data is collected only once, typically over a specific period, such as one month, to answer the research questions. This method is suitable when researchers want a snapshot of the phenomenon being studied at a specific point in time without tracking changes or developments over time. Therefore, by using the survey method on a large population and collecting data cross-sectionally, this research aims to produce valid and reliable findings. These findings can be used for decision-making and operational improvements at PD Utama Jaya Plasindo, particularly in the production department. This research centers on optimizing production across four types of products using Linear Programming (LP) to maximize profit (Utomo, Argo, & Hermanto, 2013). LP is a mathematical method used to find the best possible outcome in a mathematical model with linear relationships, particularly useful in resource allocation scenarios aimed at maximizing or minimizing quantities under constraints. By applying LP, the study aims to pinpoint the optimal production levels for each product type, leading to the highest possible profit. Variables such as production quantities, resource availability, and cost factors are defined, with constraints encompassing limitations in raw materials, labor, and machinery, while the objective function is to maximize total profit.

Operationalizing these variables ensures accurate and consistent measurement. For instance, production quantities can be measured in units, resource availability in hours or material quantities, and cost factors in monetary terms. This clear definition enables systematic analysis of how changes in production strategies impact overall profitability. Ultimately, this LP analysis will yield valuable insights into optimizing production processes at PD Utama Jaya Plasindo. The findings will empower data-driven decisions, enhancing efficiency and profitability in line with the overarching goal of improving operational performance. In this study, the four variables under examination are the number of GRX 25 productions, total production of GTW 25, total production of GTX 25, and total production of GTX 25M.

RESULTS AND DISCUSSIONS

Production Constraints of PD Utama Jaya Plasindo.

In this research, the research variables are defined based on variables or sub-variables present in the study. The concept of variables or sub-variables is defined according to the definitions relevant to the research, supported by the underlying theory. Indicators are aspects that can be observed or measured to explain the variables or sub-variables in the study. Therefore, research variables are essentially any elements established in a study to be examined, allowing for the acquisition of information about those elements, from which conclusions can be drawn. In other words, a research variable is an attribute, characteristic, or value of a person, object, or activity that has certain variations set by the researcher for analysis or conclusion. The discussion will focus on the optimization of production across four product types using the concept of Linear Programming to maximize profit. Table 1 presents the operationalization of the research variables.

Table 1 Operationalization of Research Variables

Variable	subvariable	Indicator	size
Determining Decision Variables	1. GRX 25 2. GTW 25 3. GTX 25 4. GTX 25 M	1. Production quantity of GRX 25 2. Production quantity of GTW 25 3. Production quantity of GTX 25 4. Production quantity of GTX 25M	nominal

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objective function	$Z_{max=c1x1+c2x2+c3x3+c4x4}$	1. Maximizing the total profit obtained from the GRX 25 product. 2. Maximizing the total profit obtained from the GTW 25 product. 3. Maximizing the total profit obtained from the GTX 25 product. 4. Maximizing the total profit obtained from the GTX 25 M product.	
constraint function	Raw Materials: $a_{11}x_1+a_{12}x_2+a_{13}x_3+a_{14}x_4 \leq b_1$ Machine Working Hours: $a_{21}x_1+a_{22}x_2+a_{23}x_3+a_{24}x_4 \leq b_2$ Labor Hours: $a_{31}x_1+a_{32}x_2+a_{33}x_3+a_{34}x_4 \leq b_3$ Product Demand for GRX 25: $a_{41}x_1 \leq b_4$ Product Demand for GTW 25: $a_{51}x_1 \leq b_5$ Product Demand for GTX 25: $a_{61}x_1 \leq b_6$ Product Demand for GTX 25 M: $a_{71}x_1 \leq b_7$	The left-hand side must not exceed the right-hand side. Availability of raw materials: b_1 Availability of machine working hours: b_2 Availability of labor hours: b_3 Market demand for product A: b_4 Market demand for product B: b_5 Market demand for product C: b_6 Market demand for product D: b_7	nominal

The following description will detail the equations of seven constraint functions and provide a brief overview of the objective function. The objective function, which aims to maximize profit mathematically, can be expressed as follows:

Profit = 37A+46B+ 38C+46D

In this case, the numbers 37, 46, 38, and 46 are constant values, while the letters A, B, C, and D represent variables. Variables are the parameters whose values depend significantly on the results of the calculations.

Here is a summary of the equations for the seven constraint functions that limit production:

First Constraint: Raw Materials = 7 A + 5.8 B + 8.6 C + 7.6 D ≤ 180,000 grams

Second Constraint: Machine Working Hours = 2.5 A + 3 B + 2 C + 2.5 D ≤ 86,400 seconds

Third Constraint: Labor Hours = 5 A + 5 B + 5 C + 5 D ≤ 115,200 seconds

Fourth Constraint: Demand for GRX 25 = A ≤ 2,400 units

Fifth Constraint: Demand for GTW 25 = B ≤ 7,200 units

Sixth Constraint: Demand for GTX 25 = C ≤ 3,000 units

Seventh Constraint: Demand for GTX 25 M = D ≤ 6,600 units

Furthermore, a detailed explanation of the equations for the seven constraint functions will be provided.

Based on data obtained from PD Utama Jaya Plasindo, it is known that the profit or profit margin per unit of goods is calculated using several main components. First, the total production cost is calculated with the formula:

(1) Total production cost = (cost of raw materials per kg / ((1000 grams – 100 grams) / grams of goods)) + cost.
(2) Thus, the total production cost = (Rp. 5,000 / ((1000 grams – 100 grams) / grams of goods)) + cost.
(3) Profit = Selling price – Total production cost.

Thus, to calculate the net profit per unit of goods, we subtract the total production cost from the selling price. Furthermore, based on these calculations, a linear equation can be made that represents the profit from various types of goods produced by PD Utama Jaya Plasindo. For example, if A, B, C, and D represent the number of units of four different types of goods, the total profit equation can be expressed as follows:

$Profit = 37A + 46B + 38C + 46D$

In this equation, each coefficient represents the profit margin per unit for each type of goods. In other words, the total profit generated by the company is the sum of the profit margin per unit multiplied by the number of units sold for each type of goods.

This linear equation is very useful for predicting the company's profit based on the number of units sold for each type of goods. By knowing the cost of raw materials, production costs, and selling prices, the company can easily calculate the profit that will be obtained and perform better business planning. This model also allows the company to conduct sensitivity analysis on changes in raw material prices, selling prices, or production quantities to see how these changes will affect the total profit.

The primary objective of the company is, of course, to maximize profit as much as possible. However, there are several constraints that the company faces in producing plastic buckles.

(1) One of the main constraints is the limited availability of plastic resin. The company receives an estimated 2000 kg (or about 2 tons) of plastic resin daily. However, only about 10% of the available resin is used for injecting plastic buckles each day. This limitation in raw materials affects the production capacity and requires efficient resource management to ensure continuous production.

(2) Another significant constraint is the usage of machinery. The machines operate 24 hours a day, with each injection cycle taking 30 seconds. Despite this continuous operation, the machines need to be stopped for maintenance every two weeks. This scheduled downtime affects overall productivity and requires careful planning to minimize its impact on production output. By addressing these constraints, the company aims to optimize its production process and enhance its profitability. Nevertheless, it is assumed that the machines can operate every day without any breakdowns.

(3) The next constraint is the limitation of working hours for the labor force, which is divided into two shifts: the day shift from 07:00 to 19:00 and the night shift from 19:00 to 07:00. Each worker requires approximately 5 seconds to cut one buckle, with effective working hours assumed to be 8 hours per shift. Additionally, each machine is operated by one worker.

(4) The following constraint is the estimated demand for the GRX 25 product, which is calculated based on the average monthly demand and then divided by 20 working days (active days).

(5) Similarly, the estimated demand for the GTW 25 product is also calculated based on the average monthly demand and divided by 20 working days (active days).

(6) Furthermore, the estimated demand for the GTX 25 product is calculated using the same method, based on the average monthly demand and divided by 20 working days (active days).

(7) Finally, the estimated demand for the GTX 25 M product is also calculated based on the average monthly demand and divided by 20 working days (active days).

Considering all these constraints, the company needs to manage its resources and production schedule very effectively to meet demand and maximize profits.

Constraint of Limited Plastic Resin Raw Material

The constraint of limited plastic resin raw material occurs due to the limited daily production of plastic resin. Consequently, the supply of plastic resin raw material for our company is also restricted. Sometimes, the supply of raw materials for plastic resin production is limited, resulting in increased prices of plastic resin raw materials. The available plastic resin must be used to manufacture various products, including plastic buckles, which also face limitations.

Based on the data, a linear equation is formulated to depict the first constraint:

Raw Material $=7A+5.8B+8.6C+7.6D \leq (200\text{ kg} - 10\% \times 200\text{ kg})$

$=7A+5.8B+8.6C+7.6D \leq 180{,}000$ grams

In this equation, the variables A, B, C, and D represent the quantity of four different types of items requiring plastic resin raw material. This constraint indicates that the total plastic resin raw material used to produce various products, including plastic buckles, must not exceed 180,000 grams, which is 200 kg minus 10% of that amount.

Machine Usage Constraint (Machine Working Hours)

Machine usage naturally comes with operational hour limitations. However, acquiring new machines entails significantly high costs. The constraint of machine usage lies in the fact that the machines operate 24 hours every day, with each printing cycle taking 30 seconds. The machines halt operations every two weeks. Nevertheless, it is assumed that the machines can operate every day. The formula to calculate machine operating hours in producing each plastic buckle is as follows:

Machine Operating Hours=Time for 1x I njection/Mold Capacity.

Based on the calculated machine operating hours for each product, the linear equation for the second constraint is derived as follows:

Machine Operating Hours $=2.5A+3B+2C+2.5D \leq 86{,}400$ seconds. Where 86,400 seconds is equivalent to 24 hours multiplied by 60 minutes and multiplied again by 60 seconds.

Machine Usage Constraint (Machine Working Hours)

Machine usage naturally comes with operational hour limitations. However, acquiring new machines entails significantly high costs. The constraint of machine usage lies in the fact that the machines operate 24 hours every day, with each printing cycle taking 30 seconds. The machines halt operations every two weeks. Nevertheless, it is assumed that the machines can operate every day. The formula to calculate machine operating hours in producing each plastic buckle is as follows:

Machine Operating Hours =
Time for 1x Injection/Mold Capacity.

Based on the calculated machine operating hours for each product, the linear equation for the second constraint is derived as follows:

Machine Operating Hours $=2.5A+3B+2C+2.5D \leq 86{,}400$ seconds. Where 86,400 seconds is equivalent to 24 hours multiplied by 60 minutes and multiplied again by 60 seconds.

The Constraint of Limited Working Hours for Workers

The constraint of limited working hours for workers is that each worker has a 12-hour shift, divided into two shifts. The first shift is during the day, from 07:00 to 19:00, and the second shift is at night, from 19:00 to 07:00. Each worker is estimated to take about 5 seconds to cut one buckle. However, their active working hours are assumed to be only 8 hours per day, considering the necessary breaks and rest periods.

Currently, there are 4 workers involved in the buckle-cutting process. Adding more workers is considered inefficient because additional workers will not work optimally due to various factors such as time management, coordination, and workspace limitations.

Based on the available data, we can create an equation to calculate the effective working time constraint for these four workers. Each worker takes 5 seconds to cut one buckle, so the total time used by the four workers to cut buckles in one day can be calculated with the following equation:
Labor Hours=5A+5B+5C+5D≤115,200 seconds

This equation is based on the total number of seconds available for the four workers in one day, which is 115,200 seconds (4 workers × 8 active working hours × 60 minutes × 60 seconds). By understanding this constraint, the company can plan and manage production more effectively, ensuring that the available working time is used optimally without compromising the workers' well-being.

Estimated Demand Constraints for GRX 25

There is a constraint on demand because not all products can be absorbed by the market, or in other words, not all products sell. A product mix is needed to ensure that the products produced do not accumulate and can be sold according to the estimated demand. Based on this, the concept of Linear Programming is essential to determine the optimal product mix that PD Utama Jaya Plasindo should produce to maximize profit.

The demand constraint for GRX 25 is calculated based on the average monthly demand and divided by 20 active days. The average monthly demand for the product is calculated as the total demand over 18 months divided by 18 months. The average daily demand is then calculated by dividing the average monthly demand by 20 days.
Average demand for GRX 25 = Total demand for GRX 25 / 18 months = 71,000 dozen / 18 months = 3,944 dozen per month

With these calculations, the average daily demand for GRX 25 is:
Average daily demand for GRX 25 = Average monthly demand / 20 days = 3,944 dozen / 20 days = approximately 197 dozen per day or about 2,400 pcs per day.

Based on the calculation of the demand for the GRX 25 product, a linear equation for the fourth constraint is obtained, which is:
Demand for GRX 25 = A ≤ 2,400 pcs

By understanding this constraint, PD Utama Jaya Plasindo can optimize its production process by producing the amount of GRX 25 that matches market demand, thereby avoiding the accumulation of unsold products and maximizing the company's profit.

Estimated Demand Constraint for GTW 25

The demand constraint for GTW 25 is calculated based on the average monthly demand, divided by 20 active working days. The average monthly demand for the product is calculated by dividing the total demand over 18 months by the number of months. Then, the average daily demand is obtained by dividing the average monthly demand by 20 active working days.
Average demand for GTW 25 = Total demand for GTW 25 / 18 months =

212,680 dozen / 18 months = 11,815 dozen per month

With these calculations, the average daily demand for GTW 25 is: Average daily demand for GTW 25 = Average monthly demand / 20 days = 11,815 dozen / 20 days = approximately 591 dozen per day or about 7,200 pcs per day.

Based on the calculation of the demand for the GTW 25 product, a linear equation for the fifth constraint is obtained, which is:

Demand for GTW 25 = B ≤ 7,200 pcs

By understanding this constraint, PD Utama Jaya Plasindo can optimize its production process by producing the amount of GTW 25 that matches market demand. This helps to avoid the accumulation of unsold products and ensures that the company can maximize the profit obtained.

The constraint of estimated demand for GTX 25

The estimated demand constraint for GTX 25 is calculated based on the average demand for each month, which is then divided by the number of active days in a month (20 days). The average demand for the product each month is calculated by dividing the total demand over 18 months by the number of months. Subsequently, the average daily demand for the product is obtained by dividing the average monthly demand by 20 working days.

The average demand for GTX 25 = Total demand for GTX 25 / 18 months = 87,700 dozen / 18 months = 4,872 dozen per month

Thus, based on the calculation of demand for GTX 25, a linear equation for the sixth constraint is obtained, which is:

Demand for GTX 25 = C ≤ 3,000 pcs

By understanding this constraint, the company can optimize its production planning to align with the market demand for GTX 25. This approach helps prevent product inventory buildup and ensures production aligns with demand, thereby maximizing profitability.

The constraint of Estimated Demand for GTX 25 M

The estimated demand constraint for GTX 25 M is calculated based on the average demand for each month, divided by the number of active days in a month (20 working days). The average demand for the product each month is calculated by dividing the total demand over 18 months by the number of months. Subsequently, the average daily demand for the product is obtained by dividing the average monthly demand by 20 working days.

The average demand for GTX 25 M = Total demand for GTX 25 M / 18 months = 197,470 dozen / 18 months = 10,970 dozen per month

Based on the calculation of demand for GTX 25 M, a linear equation for the seventh constraint is obtained, which is:

Demand for GTX 25 M = D ≤ 6,600 pcs

Explanation: Each package contains 10 dozen, thus the demand is converted into multiples of 10 dozen to align with the demand unit in dozens.

By understanding this constraint, the company can optimize its production planning to align with the market demand for GTX 25 M. This approach helps prevent product inventory buildup and ensures production aligns with demand, thereby maximizing profitability.

PD Utama Jaya Plasindo employs Linear Programming analysis through the Matlab (Zaini, 2017) program to optimize the mix of plastic buckle products, aiming to maximize overall profit. The objective function is represented as:

Profit = 37A + 46B + 38C + 46D

There are seven production constraints as follows:

1. Raw Material: 7A + 5.8B + 8.6C + 7.6D ≤ 180,000 grams

2. Machine Working Hours: 2.5A + 3B + 2C + 2.5D ≤ 86,400 seconds
3. Labor Hours: 5A + 5B + 5C + 5D ≤ 115,200 seconds
4. Demand for GRX 25: A ≤ 2400 pcs
5. Demand for GTW 25: B ≤ 7200 pcs
6. Demand for GTX 25: C ≤ 3000 pcs
7. Demand for GTX 25 M: D ≤ 6600 pcs
8. From the description of the objective function in terms of profit and the explanation of the seven constraint functions, a summary can be presented in the following table:

Table 2. Data on Objective Function and Constraint Functions

	GRX 25	GTW 25	GTX 25	GTX 25 M		RHS
Maximize:	37	46	38	46		
Raw Materials	7	5,8	8,6	7,6	<=	180000
Machine Working Hours	2,5	3	2	2,5	<=	86400
Labor Hours	5	5	5	5	<=	115200
Demand for GRX 25	1	0	0	0	<=	2400
Demand for GTW 25	0	1	0	0	<=	7200
Demand for GTX 25	0	0	1	0	<=	3000
Demand for GTX 25 M	0	0	0	1	<=	6600

From Table 2, this can serve as a basis for calculations to achieve maximum profit.

These calculations are conducted using Matlab for Windows. The results offer the optimal product mix to maximize the company's total profit.

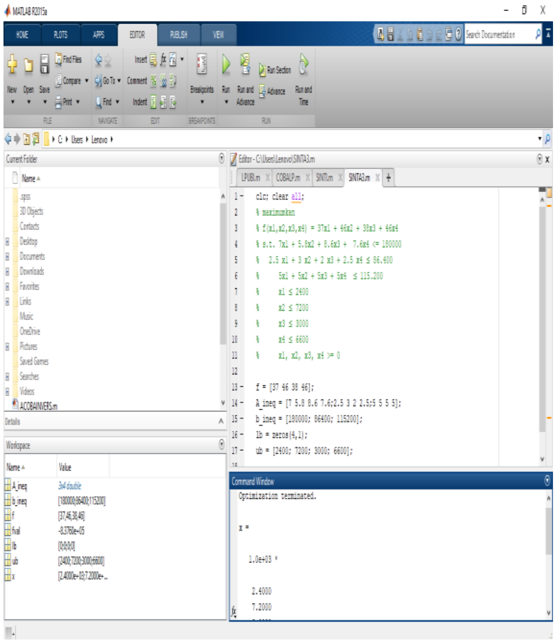

Figure 1. The source code of linear programming calculations using Matlab

It should be noted here that, for the sake of convenience in calculations based on MATLAB source code, the variables A, B, C, and D will temporarily be replaced by the variables x_1, x_2, x_3, and x_4.
These are source codes from Matlab that can be written as follows, sourced from data table 2.

clc; clear all;
% maximum an
% $f(x_1,x_2,x_3,x_4) = 37x_1 + 46x_2 + 38x_3 + 46x_4$
% s.t. $7x_1 + 5.8x_2 + 8.6x_3 + 7.6x_4 <= 180000$
% $2.5 x_1 + 3 x_2 + 2 x_3 + 2.5 x_4 <= 86.400$
% $5x_1 + 5x_2 + 5x_3 + 5x_4 <= 115.200$
% $x_1 <= 2400$
% $x_2 <= 7200$
% $x_3 <= 3000$
% $x_4 <= 6600$
% $x_1, x_2, x_3, x_4 >= 0$
f = [37 46 38 46];
A_ineq = [7 5.8 8.6 7.6;2.5 3 2 2.5;5 5 5 5];
b_ineq = [180000; 86400; 115200];
lb = zeros(4,1);
ub = [2400; 7200; 3000; 6600];

The Matlab (Funny, 2017) source code and the linear equation systems depicted in Figure 1 clearly illustrate the application of applied mathematics (Riatinda, 2022). Applied mathematics involves using mathematical principles to tackle real-world problems across various domains, including business, surveys, engineering, and social sciences. In this research context, the focus is on a concrete business problem related to plastic production. Specifically, the goal is to maximize profit by optimizing the production of various types of plastic products. By leveraging applied mathematics, particularly linear programming techniques, companies can determine the ideal product mix that will yield the highest profit. With tools like Matlab (Putra et al., 2020), the calculation and analysis processes become streamlined and more precise. This enables companies to make well-informed decisions based on data, particularly in areas like production planning, resource allocation, and marketing strategies. Ultimately, the application of applied mathematics not only resolves specific challenges but also enhances overall operational efficiency and competitiveness in the market.

While the result from linear programming can be described here.

x =

$1.0e^{+03}$ *

2.4000

7.2000

3.0000

6.6000

fval =

$-8.3760e^{+05}$

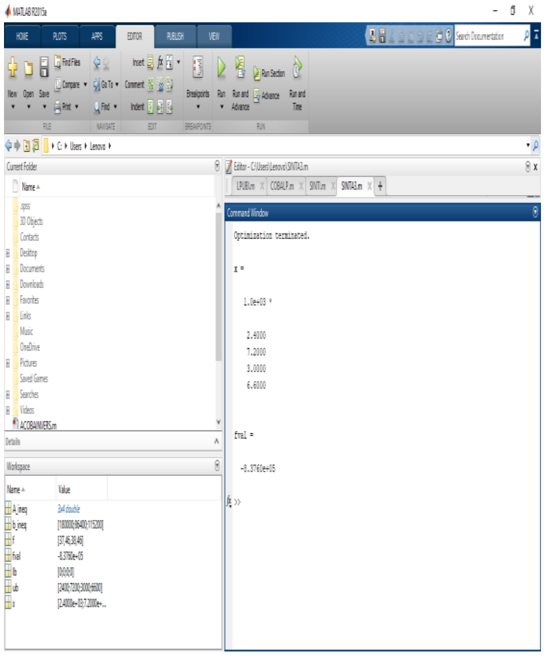

Figure 2. Calculation results using Matlab software

Based on Figure 2, the results of the Linear Programming analysis using Matlab (Jain, 2017) reveal the optimal production solution that aligns to maximize profit. The recommended production quantities are as follows: 2,400 pieces of GRX 25 plastic buckles, 7,200 pieces of GTW 25 plastic buckles, 3,000 pieces of GTX 25 plastic buckles, and 6,600 pieces of GTX 25 M plastic buckles. The maximum profit generated by PD Utama Jaya Plasindo in 2010, under constant conditions for plastic buckle products, is calculated as follows:

Profit = 37A + 46B + 38C + 46D

Profit = 37 [2,400] + 46 [7,200] + 38 [3,000] + 46 [6,600]

= 88,800 + 331,200 + 114,000 + 303,600

= Rp. 837,600 per day.

It is important to note that the variables x_1, x_2, x_3, and x_4 in Matlab (Singh et al., 2019) correspond to the variables A, B, C, and D in this research report. This analysis provides a clear understanding of how the company can optimally allocate its production resources to achieve maximum profit. Implementing this solution is expected to enhance the company's production efficiency and profitability. Additionally, it underscores the importance of using analytical tools like Matlab (Rahma et al., 2017) for making complex business decisions, particularly in determining the most profitable product mix. The figures obtained from data processing using Matlab-based linprog, ranging from 2,400 to 837,600 rupiah in daily profits, are crucial control or regulatory metrics for agents in the industrial sector. These figures serve as benchmarks for managing various industrial activities, such as plastic production or other processes. With these control figures, companies can perform their roles as industrial agents more effectively and efficiently. These benchmarks enable companies to estimate potential profits on a daily, weekly, or monthly basis. Additionally, these control figures help companies plan and optimize their production processes, enhancing overall productivity and profitability. As a result, companies can make more accurate decisions based on precise data, minimize the risk of losses, and ensure that industrial operations run smoothly and meet their targets.

Based on the objective function, the following information was obtained:

- The profit from GRX 25 plastic buckles is Rp. 37 per piece, with a daily production of 2,400 pieces to maximize profit. The daily revenue from GRX 25 (A) is Rp. 88,800.
- The profit from GTW 25 plastic buckles is Rp. 46 per piece, with a daily production of 7,200 pieces to maximize profit. The daily revenue from GTW 25 (B) is Rp. 331,200.
- The profit from GTX 25 plastic buckles is Rp. 38 per piece, with a daily production of 3,000 pieces to maximize profit. The daily revenue from GTX 25 (C) is Rp. 114,000.
- The profit from GTX 25 M plastic buckles is Rp. 46 per piece, with a daily production of 6,600 pieces to maximize profit. The daily revenue from GTX 25 M (D) is Rp. 303,600.

Therefore, the total daily profit for PD Utama Jaya Plasindo is Rp. 837,600. Assuming 20 active working days per month, the total monthly profit would be Rp. 16,752,000. This calculation assumes that the profit aligns with the objective function and remains within the constraints. The usage of plastic resin as a raw material has also been carefully calculated. The required raw material is based on the following formula: Raw Material = 7A + 5.8B + 8.6C + 7.6D ≤ 180,000 grams. According to this calculation, the result is:

- Raw Material = 7 [2,400] + 5.8 [7,200] + 8.6 [3,000] + 7.6 [6,600]
- = 16,800 + 41,760 + 25,800 + 50,160
- = 134,520 grams

Thus, the total usage of plastic resin is 134,520 grams, which is below the maximum allowed usage of 180,000 grams. These results indicate that the proposed production plan not only maximizes profit but also efficiently uses raw materials. Implementing this production strategy is expected to significantly enhance the company's efficiency and profitability.

The remaining raw material is 180,000 grams – 134,520 grams = 45,480 grams. Based on the first constraint function, which is the linear equation for the use of plastic resin, the following information is obtained:

- The raw material usage for GRX 25 (A) is 16,800 grams or 16.8 kg.
- The raw material usage for GTW 25 (B) is 41,760 grams or 41.76 kg.
- The raw material usage for GTX 25 (C) is 25,800 grams or 25.8 kg.
- The raw material usage for GTX 25 M (D) is 50,160 grams or 50.16 kg.

Thus, after meeting the raw material needs for all these products, there are still 45,480 grams or 45.48 kg of raw material left. This remaining raw material indicates that the use of raw materials has been efficiently managed and does not exceed the maximum limit set. The implementation of this raw material usage plan is expected to support sustainable production and reduce waste, ultimately increasing the company's efficiency and profitability.

The utilization of machine working hours is calculated as follows:

Machine Working Hours = 2.5A + 3B + 2C + 2.5D $\leq$ 86,400 seconds

= 2.5 [2,400] + 3 [7,200] + 2 [3,000] + 2.5 [6,600]

= 6,000 + 21,600 + 6,000 + 16,500

= 50,100 seconds

Thus, the remaining machine working hours are 86,400 seconds – 50,100 seconds = 36,300 seconds. Based on the second constraint function, which is the linear equation for machine working hours usage, the following information is obtained:

- Machine working hours usage for GRX 25 (A) is 6,000 seconds or 1.67 hours.
- Machine working hours usage for GTW 25 (B) is 21,600 seconds or 6 hours.
- Machine working hours usage for GTX 25 (C) is 6,000 seconds or 1.67 hours.
- Machine working hours usage for GTX 25 M (D) is 16,500 seconds or 4.58 hours.

Therefore, the remaining machine working hours are 36,300 seconds or 10.08 hours. This indicates that the utilization of machine working hours has been efficiently managed, leaving available production time to fulfill other production needs.

The utilization of labor hours is calculated as follows:

Labor Hours = 5A + 5B + 5C + 5D $\leq$ 115,200 seconds

= 5 [2,400] + 5 [7,200] + 5 [3,000] + 5 [6,600]

= 12,000 + 36,000 + 15,000 + 33,000

= 96,000 seconds

So, the remaining labor hours are 115,200 – 96,000 = 19,200 seconds

Based on the third constraint function, which is the linear equation for labor hours usage, the following information is obtained:

- Labor hours usage for GRX 25 (A) is 12,000 seconds or equivalent to 3.33 hours.
- Labor hours usage for GTW 25 (B) is 36,000 seconds or equivalent to 10 hours.
- Labor hours usage for GTX 25 (C) is 15,000 seconds or equivalent to 4.17 hours.
- Labor hours usage for GTX 25 M (D) is 33,000 seconds or equivalent to 9.17 hours.

Therefore, the remaining working hours are 19,200 seconds, or equivalent to 5.33 hours.

The demand for GRX 25 has been adequately met, considering the maximum production achievable is 2400 pcs. Similarly, the demand for GTW 25 has also been fulfilled as the maximum production achievable is 7200 pcs. As for GTX 25, the demand has also been met with a maximum production capacity of 3000 pcs. Meanwhile, the demand for GTX 25 M has also been satisfied with a maximum production capacity of 6600 pcs. Thus, all product demands have been fulfilled according to the available production capacity.

CONCLUSION

Based on the results from Linear Programming analysis using MATLAB's linprog, we conclude that PD Utama Jaya Plasindo can maximize profits by considering several key factors. These factors include raw material availability, machine operating hours, labor hours, and the demand for products GRX 25, GTW 25, GTX 25, and GTX 25 M. The recommended production quantities are 2400 units of GRX 25 plastic buckles, 7200 units of GTW 25 plastic buckles, 3000 units of GTX 25 plastic buckles, and 6600 units of GTX 25 M plastic buckles. By following these recommendations, the company can achieve a maximum daily profit of Rp. 837,600 from plastic buckle production. These figures serve as control benchmarks to ensure the company reaches its maximum profit potential. They provide clear quantitative guidance and assist in planning and implementing more effective production strategies. Presenting this information as a system of linear equations and MATLAB code helps address the complex mathematical challenges faced by the plastic processing industry.

The mathematical model facilitates formulating and solving optimization problems while considering various constraints. MATLAB's linprog tool enables quick and accurate simulations and analyses, allowing business decisions to be based on reliable data. Applying linear programming and computational technology not only enhances operational efficiency but also provides a significant competitive edge. Consequently, PD Utama Jaya Plasindo can better respond to market changes, optimize resource use, and boost profitability. With a daily profit of Rp. 837,600 and a monthly total of Rp. 16,752,000 (assuming 20 active working days), the company can expect consistent and substantial monthly revenue from plastic buckle production.

It can also recommend a few key steps for the future. First, if the company plans to increase production, it should consider additional development costs and optimize the use of all available production capacity. Furthermore, addressing the environmental impact of increased plastic production by adopting more proactive recycling practices in line with public concerns and government regulations is crucial. Second, for long-term growth, exploring trend analysis can drive innovation and enhance market knowledge. This approach provides deeper insights into market trends and shifting consumer demands, guiding future business strategies. Additionally, integrating dynamic and adaptive statistical analysis will help the company quickly adapt to changing market conditions. By combining these methods, the company can make more informed decisions and navigate the dynamic business environment more effectively.

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