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OPTIMAL SCHEDULING OF GAS STATION ATTENDANT USING INTEGER LINEAR PROGRAMMING METHOD (Study On Gas Station 44.574.03 Jonggrangan Klaten)

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Abstract : *Gas Station (SPBU) generally serve the needs of consumers 24 hours a day. The problem of employee scheduling is a problem that is often faced by companies because scheduling that is not optimal can cause wasted costs. The rules applied by the gas station company and the limited number of employees are the determining factors in the preparation of the employee schedule. This scheduling problem can be applied to the Integer Linear Programming modeling. Integer Linear Programming is a linear programming calculation model with a linear objective function, linear constraints function, and integer variables. This employee scheduling problem is solved using the Integer Linear Programming method with the aim of minimizing employee salary costs without reducing the number of employees and not ignoring the rules and or constraints set by the company. This study discusses the problem formulation of gas station employee scheduling in the form of Integer Linear Programming in a case study at SPBU 44574.03 Jonggrangan Klaten. Mathematical formulations and models were completed with the help of the LINGO 8.0 computer application.*

Keywords*: gas stations, employee scheduling, integer linear programming, minimum cost*

1. Introduction

The needs of the community regarding the mobility of each person is now an important thing in society. Along with the increasing use of motorized vehicles, the demand for fuel oil (BBM) is also increasing. Public Fuel Filling Stations (SPBU) as a place for the community to provide fuel filling services are the main destination when people need fuel for their vehicles. Fuel filling machine operators must be prepared at all times when serving the community, because the need for fuel in the community must be available 24 hours. This refers to human resources as operators at gas stations that are limited and not possible to be available at all times. Therefore, in its development, a scheduling system for dispatchers at gas stations was created, which aims to organize the duty time of dispatchers so that gas stations can be ready to serve the community at all times. Because of the importance of employee scheduling for companies, the management of gas stations must also arrange efficient and optimal scheduling so that the demand for gas station services is fulfilled and there is no accumulation of consumers (queues) which results in a decrease in the quality of gas station services and the use of machines that are not used if there are no machine operators. Scheduling must also be arranged optimally so that its implementation becomes

effective and efficient and fair in the eyes of the operators who perform their duties. Therefore, scheduling is carried out to optimize performance and reduce wasted costs. Gas Station (SPBU) 44.574.03 Jonggrangan is a gas station owned by PT Pertamina Persero which provides fuel needs for the community, especially in the Klaten area. By using the Integer Linear Programming method, scheduling problems can be applied to work related to employee shifts. In this study, the Integer Linear Programming method will be applied to employee scheduling which includes managers, shift chief officers, administration, and fuel filling machine operators at a Gas Station (SPBU).

2. Literature Review

Definition of Scheduling

According to Morton (1993) scheduling is defined as making decisions regarding the adjustment of work activities and resources with the aim of completing work to be on time and have the best possible quality. According to Render and Hanna (2012) scheduling is closely related to the selection of the timing of activities or work operations. To start the scheduling decision is done with capacity planning which includes the availability of resources owned as a whole. The purpose of scheduling decisions is to allocate and prioritize demand (generated by forecasts or consumer orders) on available facilities or assets. The type of forward or backward scheduling and prioritization criteria are two important factors in performing work division and prioritization. There are differences in the scheduling systems of service companies and manufacturing companies. In manufacturing companies, the main concern is the availability of machinery and raw materials. In contrast to manufacturing companies, service companies emphasize the arrangement of human resources or employees by taking into account several considerations such as workers' rights, wages, working hours, etc. The main objective in scheduling in service companies is to determine scheduling with the minimum number of workers needed to meet consumer demand by paying attention to optimizing service to consumers.

Scheduling Problems

Scheduling problems are situations that require the preparation of job allocation to machines or human resources where the condition of machines or human resources has a limited capacity and number. In general, the scheduling problem can be described as n jobs (J1, J2, ...,Jn) that must be done on m machines or humans (M1, M2, ...,Mn). The goal of good scheduling is to get an optimum schedule arrangement, which means that machines or humans can complete all jobs by getting an optimum schedule, namely completing all jobs in the presence of limited machine or human capacity to fulfill the objective function.

Scheduling Objectives

The purpose of scheduling is to find a point between human and work factors that produces an optimum solution in the application of the schedule. Scheduling can also increase machine/facility or human productivity and reduce wasted time (idle). By increasing productivity, idle time can be reduced, and indirectly the company can minimize production costs. With a good improvement in scheduling, it is directly proportional to the improvement of company performance and can be a reference for increasing work productivity and strategies for companies in customer satisfaction. Some of the objectives to be achieved by scheduling are as follows (Baker & Trietsch, 2009):

1. Increase productivity, by reducing wasted machine or human time (idle).

2. Reduce the inventory of semi-finished goods by reducing the average number of jobs waiting in line for a machine because the machine is busy.
3. Reduce delays due to exceeding time limits by,
   a. Reducing the maximum delay,
   b. Reducing the number of late jobs. 4. Minimizing production costs.
4. Fulfillment of the deadline that has been set (due date), because in reality if there is a delay in meeting the due date, the consequences of a penalty can be imposed.

Linear Programming

According to Render and Hanna (2012) Linear Programming is a method or mathematical model that is often used by researchers or decision makers to plan and make decisions needed for the allocation of resources owned by the company. Meanwhile, according to S. Hillier and Liebermen (2012) the word linear means that all mathematical functions used in the model are required to be mathematical linear functions. The word programming refers to a system for planning. Thus, linear programming involves planning activities to obtain optimal results, that is, results that achieve the best and optimal goals among all available alternatives. According to S. Hillier and Liebermen (2012), the standard form of LP is as follows:

Maximum/minimum f = $(c_1x_1 + c_2x_2 + \cdots + c_nx_n)$ with constraint function:

$a_{11}x_1 + a_{12}x_2 + \cdots + c_{1n}x_n \leq atau \geq b_1$

$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \leq atau \geq b_2$

$a_{m1}x_1 + a_{m2}x_2 + \cdots + c_{mn}x_n \leq atau \geq b_m$

$x_1, x_2, \ldots, x_n \geq 0$

With a description:

m = limited types of resources or facilities available.

n = the number of activities - activities that use these limited resources or facilities

xj = decision variable for the jth activity (j = 1, 2, … , n)

aij = the amount of source i required to produce each unit of output of activity j (j = 1, 2, … , m; j = 1, 2, … , n)

bi = the number of resources (facilities) i available to be allocated to each unit of activity (i = 1, 2, … , m)

cj = the increase in the value of ○ when the level of activity (xij) increases by one unit or is the contribution of each unit of the overall activity j to the value of f .

f = optimized value (maximum or minimum)

There are many linear equation models that do not always match the problems faced in reality. Therefore, there is a type of linear equation that can use binary numbers, namely Integer Linear Programming.

Integer Linear Program

Integer Linear Program is a mathematical linear program that uses integers. Linear Program problem solving can generally be real numbers that allow solving in the form of fractional numbers. Rounding to integer can deviate far from the expected if the fractional linear program problem solving is converted to integer rounding. But not all real-life problems are compatible with linear programming results. Therefore, decision makers need problem solving in the form of integer decision variables so that in its application a realistic and optimal solution is obtained. Integer

Linear Programming is a development of the parent Linear Program where some or all decision variables require integer values. Mixed Integer Program (mixed Integer Progamming) is if only some of the decision variables are integer. Pure Integer Program (pure Integer Progamming) is if all decision variables are integer. While 0-1 Integer Program is a form of Integer Program where all decision variables require to be integer 0 or 1 (binary). If the decision variables are required to be 0 (zero) or 1 (one). This condition is found in cases where the problem at hand is a "yes" or "no" decision problem.

3. Research Method

Flowchart

The flow used for this research is to minimize costs through employee scheduling optimization using scheduling decisions based on the number of managers, shift heads, administration, male operators and female operators on each shift per day in one schedule period. By performing scheduling optimization, a scheduling decision will be generated that will arrange each employee manager, shift head, administration, male operator, and female operator whether to work on a certain shift on a certain day or not work on a certain shift on a certain day. By combining optimization in each employee division, scheduling optimization will be produced which will lead to cost optimization.

Research Design and Variables

Secondary data analysis is the approach used for this research. Meanwhile, the method used is descriptive quantitative research analysis. The secondary data analysis method is a research method using secondary data as the main data source (Anang, 2011). Secondary data research uses appropriate statistical test methods to produce the expected answers from data obtained from related agencies or companies. This study aims to obtain an overview of the data and facts relating to the scope of the problem to be studied, therefore descriptive research is carried out.

The research variable used in the preparation of this research is the shift work scheduling decision variable. Scheduling decision variables are used to formulate the objective function and constraint function mathematically. The variable of scheduling is to determine the start and end time of the dispatcher on duty. Scheduling in this study refers to the decision to determine the number and when managers, shift heads, administration, and dispatchers will be on duty to achieve scheduling optimization. The scheduling decision variable in this study can be defined as determining whether employee c can be assigned to shift a on day b or employee c cannot be assigned to shift a on day b. In this study, observation was used as a research instrument. Observation or observation is an activity of paying careful attention to the object of research. In addition, observation activities aim to record every situation that is relevant to the research objectives. Observation was carried out at SPBU 44.574.03 Jonggrangan Klaten. According to how to obtain research data, this research uses secondary data.

Data Source

Secondary data is a data source obtained not directly from the object of research. This research data refers to data and information that is already available from existing sources in related agencies or companies. Secondary data in this study was obtained by obtaining data in the

administrative field at the office of SPBU 44.574.03 Jonggrangan Klaten. The data used is data on the work schedule of employees of SPBU 44.574.03 Jonggrangan Klaten in a certain period of time and data on the income value of employees of SPBU 44.574.03 Jonggrangan Klaten in a certain period of time.

Figure 1. Flowchart of the research model

4. Data Analysis And Discussion

Problem Description

In scheduling, many factors determine the scheduling model that makes scheduling effective and efficient. Factors that affect the scheduling problem of gas station employees are the number of employees available, how many shifts are set in one day, how many employees must be available in each shift, employee holidays, and other factors. These factors must be really considered in making a scheduling model so that the system can run smoothly and not cause various kinds of problems, such as employees who do not get a day off or available employees do not reach the minimum limit so that consumers who come are not served properly. Therefore, it is necessary to form a scheduling model that can optimize existing resources and still pay attention to various factors that influence it. The following is an overview of gas station employee scheduling. In general, at gas stations that are open for 24 hours there are three shifts in the employee scheduling system, namely the morning shift, afternoon shift, and night shift. Employees involved in scheduling are managers, shift heads, administration, male operators, female operators. The objective function of this problem is to minimize employee wages incurred by the gas station. As an effort to improve service quality, the company must continue to make improvements. One of the improvements that can be used is to optimize the work shift schedule that affects the wages issued by the company. Scheduling method with linear program calculation is one method that can be used. In optimizing scheduling with linear programming, there are constraints that must be included in the model calculation. The constraints used in this scheduling model are:

1. One working period is 7 days
2. Each employee only gets a maximum of one shift per day.

3. Female operators can only work on the morning or afternoon shift.
4. Male operators can be assigned to morning, afternoon, or evening shifts.
5. There must be a number of operators corresponding to the number of refueling pumps on each shift.
6. There must be at least 1 manager and 1 shift head on each shift.
7. Each employee must get 1 or 2 days off per work period.
8. Each male operator and shift leader must serve on the night shift at least 2 times per work period.
9. Each female operator must work the morning shift at least 3 times per work period.

Decision Variable

The decision variable used in this method is in the form of a binary number system, namely 0 or 1, where when the result shows the number 0 then on shift A on day B employee C does not carry out his duties to work on that shift and where when the result shows the number 1, then on shift A on day B employee C must carry out his duties to work on that shift. In the function will be described as follows**:**

$$Xabc = \begin{cases} 1, jika\ pegawai\ C\ , mendapat\ shift\ a\ di\ hari\ ke\ b \\ 0, jika\ pegawai\ c\ tidak\ mendapat\ shift\ a\ di\ hari\ ke\ b \end{cases}$$

An objective function is a function that describes a desired goal in a linear program calculation in conjunction with constraints to obtain optimal profit from the linear program model. In this model aims to minimize the cost of salaries / wages of employees who work in one work schedule period. Which is described in the following function:

$$\begin{aligned} \min\Big(\sum_{b=1}^{m}\sum_{c=1}^{n}\Big(((MS*CM)*X_{1bc})+((AS*CM)*X_{2bc})+((NS*CM)*X_{3bc})\Big) \\ +\sum_{b=1}^{m}\sum_{c=n+1}^{o}\Big(((MS*CADM)*X_{1bc})+((AS*CADM)*X_{2bc}) \\ +((NS*CADM)*X_{1bc})\Big) \\ +\sum_{b=1}^{m}\sum_{c=o+1}^{p}\Big(((MS*CKS)*X_{1bc})+((AS*CKS)*X_{2bc}) \\ +((NS*CKS)*X_{3bc})\Big) \\ +\sum_{b=1}^{m}\sum_{c=p+1}^{r}\Big(((MS*CO)*X_{1bc})+((AS*CO)*X_{2bc}) \\ +((NS*CO)*X_{1bc}))\Big) \end{aligned}$$

Obstacles

1. In a linear program model, there must be constraints that will be related to the calculation of the model. In this case, the constraints are a model of rules in scheduling related to

work shifts that must be adhered to in making linear program models. These scheduling rules can be converted into the functions below:

2. The number of employees on duty in each shift each day must meet the needs,

$$\sum_{b=1}^{n} X_{abc} \geq TM, \forall a = 1,2, \forall b = 1,2, \ldots, n \text{ (Manajer)},$$

$$\sum_{c=n+1}^{o} X_{abc} \geq TADM, \forall a = 1,2, \forall b = 1,2, \ldots, n \text{ (Administrasi)},$$

$$\sum_{c=o+1}^{p} X_{abc} \geq TKS, \forall a = 1,2,3, \forall b = 1,2, \ldots, n \text{ (Kepala Shift)},$$

$$\sum_{c=p+1}^{q} X_{abc} \geq TOPRI, \forall a = 1,2,3, \forall b = 1,2, \ldots, n \text{ (Operator pria)},$$

$$\sum_{c=q+1}^{r} X_{abc} \geq TOWI, \forall a = 1,2, \forall b = 1,2, \ldots, n \text{ (Operator wanita)},$$

3. Each employee gets at most one shift a day.

$$X_{1bc} + X_{2bc} + X_{3bc} = 1, \forall b = 1,2, \ldots, m, \forall c = 1,2, \ldots, n \text{ (manajer)},$$

$$X_{1bc} + X_{2bc} + X_{4bc} = 1, \forall b = 1,2, \ldots, m, \forall c = n+1, n+2, \ldots, o \text{ (administrasi)},$$

$$X_{1bc} + X_{2bc} + X_{3bc} + X_{4bc} = 1, \forall b = 1,2, \ldots, m, \forall c = o+1, o+2, \ldots, p \text{ (Kepala shift)},$$

$$X_{1bc} + X_{2bc} + X_{3bc} + X_{4bc} = 1, \forall b = 1,2, \ldots, m, \forall c = p+1, p+2, \ldots, q \text{ (operator pria)},$$

$$X_{1bc} + X_{2bc} + X_{4bc} = 1, \forall c = 1,2, \ldots, m, \forall c = q+1, q+2, \ldots, r \text{ (operator wanita)},$$

4. Total hari kerja untuk setiap pegawai dalam satu periode kerja,

$$\sum_{b=1}^{m} (X_{1bc} + X_{2bc}) \geq TDM, \forall c = 1,2, \ldots, n \text{ (manajer)},$$

$$\sum_{b=1}^{m} (X_{1bc} + X_{4bc}) \geq TDADM, \forall c = n+1, n+2, \ldots, o \text{ (administrasi)},$$

$$\sum_{b=1}^{m} (X_{1bc} + X_{2bc} + X_{3bc}) \geq TSKS, \forall c = o+1, o+2, \ldots, p \text{ (kepala shift)},$$

$$\sum_{b=1}^{m} (X_{1bc} + X_{2bc} + X_{3bc}) \geq TDMO, \forall c = p+1, p+2, \ldots, q \text{ (operator pria)},$$

$$\sum_{b=1}^{m} (X_{1bc} + X_{2bc}) \geq TDFO, \forall c = q+1, q+2, \ldots, r \text{ (operator wanita)},$$

5. Each manager must work the morning and/or afternoon shift at least once a period,

$$\sum_{b=1}^{m} X_{abc} \geq SM, \forall a = 1,2, \forall c = 1,2, \ldots, n$$

6. Each Admissions Officer must work the morning and/or afternoon shift at least SADM times per period.

$$\sum_{b=1}^{m} X_{abc} \geq SADM, \forall a = 1,2, \forall c = n+1, n+2, \ldots, o$$

7. Each Shift Head must serve on the morning, afternoon and or night shift at least SKS times in one period,

$$\sum_{b=1}^{m} X_{abc} \geq SKS, \forall a = 1,2,3 \; \forall c = o+1, o+2, \ldots, p$$

8. Each male operator must work the morning and/or afternoon shift at least MDS times per period.

$$\sum_{b=1}^{m} X_{abc} \geq MDS, \forall a = 1,2, \forall c = p+1, p+2, \dots, q$$

9. Each male operator must work the night shift at least MNS times per period,

$$\sum_{b=1}^{m} X_{3bc} \geq MNS, \forall a = 3, \forall c = p+1, p+2, \dots, q$$

10. Each female operator must work the morning and/or afternoon shift at least FDS times per period,

$$\sum_{b=1}^{m} X_{abc} \geq FDS, \forall a = 1,2, \forall c = q+1, q+2, \dots, r$$

11. Each employee must have at least one vacation per work period

$$X_{1bc} + X_{2bc} + X_{3bc} + X_{1(b+1)c} + X_{2(b+1)c} + X_{3(b+1)c} + X_{1(b+2)c} + X_{2(b+2)c} + X_{3(b+2)c} + X_{1(b+3)c} + X_{2(b+3)c} + X_{3(b+3)c} + X_{1(b+4)c} + X_{2(b+4)c} + X_{3(b+4)c} + X_{1(b+5)c} + X_{2(b+5)c} + X_{3(b+5)c} + X_{1(b+6)c} + X_{2(b+6)c} + X_{3(b+6)c} \leq 6, \forall b = 1,2, \dots, (m-6) \forall c = 1,2, \dots, r.$$

12. All decision variables are integer zero or one,

$$X_{abc} \in \{0,1\}, \forall a, b, c$$

Table 1. Total employee salary before optimization in one working period

NO	JABATAN	BIAYA PER MINGGU
1	Manajer	5,267,500
2	Admin	2,450,000
3	Kepala Shift	6,300,000
4	Operator Pria	13,368,750
5	Operator Wanita	4,226,250
TOTAL		31,612,500

sumber : data diolah, 2021

In the table above, it shows the total amount of wage costs per work division that the company must incur for each work period. With the results showing a total of Rp 31,612,500.00. This value is the amount of wages that have not been optimized in linear programming.

Table 2. Total employee salary after optimization in one working period

NO	JABATAN	BIAYA PER MINGGU
1	Manajer	5,267,500
2	Admin	2,450,000
3	Kepala Shift	6,300,000
4	Operator Pria	12,376,875
5	Operator Wanita	4,226,250
TOTAL		30,663,750

sumber : data diolah, 2021

In the table above, it shows the total amount of wage costs per work division that the company must incur for each work period. With the results showing a total of Rp 30,663,750.00. This value is the amount of wages that have been optimized in linear programming.

5. Conclusions And Suggestions

Conclusion

In this research it has been shown that linear programming model can be applied in scheduling problem of gas station 44.574.03 Jonggrangan Klaten with objective function of minimizing employee salary/wage cost. The application of this linear program model is carried out based on data that has been collected at the company in secondary and interviews. In the calculation of the Linear Program model, it was successfully obtained that the amount of costs borne by the company decreased by 3.001% with a nominal value of Rp 948,750.00. For the comparison of total costs before optimization is Rp 31,612,500.00 and total costs after optimization is Rp 30,663,750.00. Total cost is the cost incurred by the company in one work schedule period, which is 7 days starting from Monday to Sunday. In conclusion, with employee scheduling optimization at SPBU 44.574.03 Jonggrangan Klaten can change employee schedules to be more effective with optimization of total employee salary costs by 3.001% every one work schedule period.

Suggestions

As explained, in companies that use a shift system in managing employee performance, an even and optimal scheduling system is needed in the distribution of assignments. The results of research on the employee scheduling system in the company in general are fairly good. However, in particular, more structured and evenly distributed scheduling is needed every day, so as to achieve optimal functions in the use of human resources and costs incurred by the company. Future researchers are expected to further develop the research model into companies that have a more complex scheduling system.

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