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Optimization of Employee Assignment Problem Base on Time Work Settlement by Using Hungarian Methods

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This research aims to optimize the assignment of employees in the sewing line area using the Hungarian assignment method. The Hungarian method is a method developed by a Hungarian mathematician named D. Konig. He aimed to overcome assignment problems by solving a weighted matrix for each task and available resources. The data used in the assignment problem are data concerning the resources and duties assigned; the results that will be obtained aim to minimizing the completion time of work. From the results of the study, after using the Hungarian method, the work completion time was 35 hours. Time efficiency was 8.3 hours compared to the time of completion before using the Hungarian method for 43.3 hours.

Key words: *The Hungarian method, assignment problem.*

Introduction

To increase the success of a business, each company should implement the right strategies or techniques in resource management. However, companies often face problems related to the optimal allocation of various productive resources, especially labor. This problem is called an Assignment Problem, where the assignment problem is a special case of the problem of linear programming. (Taha, 2010) In completing some work each employee has a difference in terms of skill level or productivity. This difference is influenced by several factors including the physical condition, knowledge, experience, interests, and personality of an employee. The assignment problem stems from the placement of workers in the available fields so that the costs borne by the company can be minimized. The problem of employee assignment can basically be performed using two methods, namely, manually and using a software program.

The manual method can be performed using the Brute Force algorithm, the penalty method, the Hungarian method, and also the transport method (Nur, 2017). If the Assignee is considered a source and an Assignment is considered a goal, then the assignment model will be the same as the transportation problem. In general, assignment problems can be expressed mathematically in a linear programming form as follows (Sonia and Puri, 2008) Minimize (maximize):

$$\text{Min } Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij} \qquad (1)$$

with constraints: :

$$\sum_{i=1}^{m} X_{ij} = \sum_{j=1}^{n} X_{ij} = 1 \qquad (2)$$

$X_{ij} \geq 0$ and C_{ij} s a known constant.

From several sources that explain the assignment problem-solving method, the Hungarian method is preferred to get the most optimal solution. The biggest advantage of using the Hungarian method is that the method used to solve the problem is very efficient in terms of its iterative efficiency. The Hungarian method is performed by means of a matrix. This problem can be explained easily in the form of a rectangular matrix, where the lines show the sources and the columns show tasks. Assignment problems have been widely used in various application contexts such as personnel rescheduling, workforce planning and resource allocation issues (Sonia and Puri, 2008) and in scheduling problems with irregular cost functions (Sourd, 2004).

In previous studies related to assignment problems and Hungarian methods, namely research from Supian et al., the results show that the calculations using the Hungarian method obtains optimal results compared to using the calculation methods commonly used by companies (Supian et al., 2018). While the results of Odior et al., study discusses the problem of the effectiveness of a viable solution from a multi-criteria assignment problem with the Hungarian method, the solution to this multi-criteria assignment problem was carried out in two steps (Odior et al., 2011). In the first step, it was determined whether or not a given feasible solution of a multi-criteria assignment problem was a really efficient one. In the second step, if the feasible solution was not really efficient, a superior solution was provided, using a proposed method which consisted of transforming the original problem into an assignment problem. The research conducted by Jain, E. et al., proposed to solve assignment problems related to the allocation of jobs for n people. The assignment problem was completed in two stages, where n1 of n jobs was the main job (Phase-I) and the remaining n2 was secondary work (Phase -II). Phase II Employment begins only after the Phase I work is completed and the aim was to find a task that minimizes the total time of completion of Phase I and Phase-II work (Jain et al., 2019).

In a study conducted by Hendri Ponda et al., it was aimed at rescheduling based on the waiting time of the Boeing 737-900ER aircraft operated by PT. Batik Air at Soekarno-Hatta Airport. The results showed that by applying the Hungarian method, overall airport waiting time could be shortened by 10,045 minutes (Ponda et al., 2018).

This research is applied to companies engaged in the garment industry, more precisely the making of apparel (convection) where the company, as established in 2010, has problems in terms of assigning employees (operators) in the sewing line area. The availability of employees (operators) is not in accordance with established company policies which has an impact on the number of products produced, namely dresses, inners, tunic products, such that targets are not reached and the cost of the sewing line budget are high. Therefore, it is necessary to assign employees (operators), in order to maximize production and minimize costs in the sewing line area.

This study aims to optimize the assignment of employees (operator) in the sewing line area by using the assignment method (Hungarian). The Hungarian method was developed by H. W. Kuhn and based on the work of two Hungarian mathematicians, Evgary and König to appreciate his work, then H. W. Kuhn named it the Hungarian algorithm (Vermaak and Van Wyk, 2010); (Harvard, 2005); (Kuhn, 1955).

Methodology

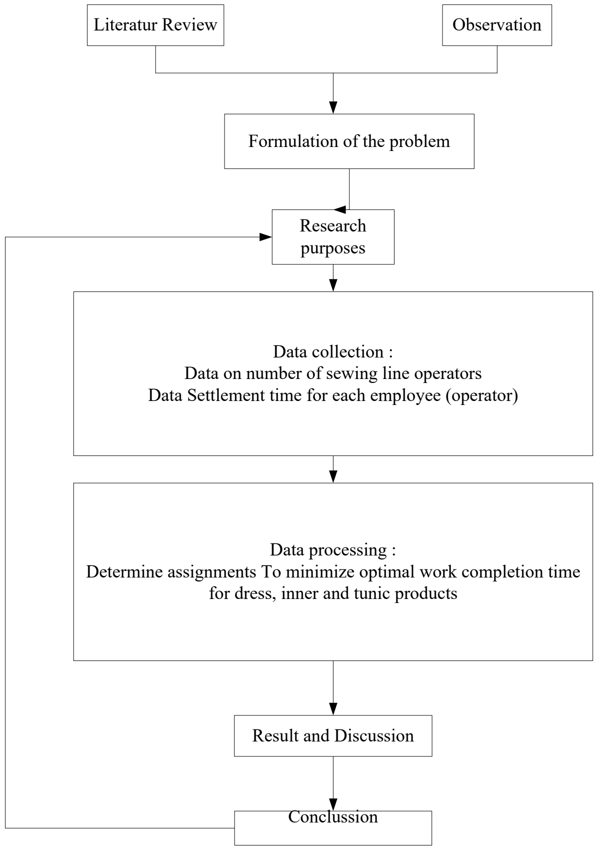
The data used are secondary data, namely data that have been recorded and processed by the place of business. In addition, supporting data are needed from the results of interviews and observations.
In carrying out this research, researchers do so by applying the methodology as follows:

1. Types of research
   The type of research used in this study is applied research.
2. Types and Data Sources
   The type of data used in this study are secondary data.

Data were taken from the company in the form of data on the number of employees, especially in the sewing line area, type of work and time of completion of work.

Data sources used in this study are sourced from one of the companies engaged in the garment industry located in Bandung. The technique of collecting data in this study was interview techniques and documentation. In terms of interviewing techniques, questions and answers were directly conducted with the employees, especially in the sewing section (interview guidelines). Whereas for documentation techniques, these were collected by archives in the company and equipped with literature studies of previous researchers. In general, the research steps can be shown in the following flow chart:

Figure 1. Flow Chart



Results and Discussion

The aim of Operational research is to try to apply direction and the best (optimum) action of a decision problem under limited resource restrictions (Taha, 2010). According to Taylor (2013) the assignment model is a special model that is part of operational research, namely a linear program model, similar to the transportation model. However, both can still be distinguished with the exception that in the model of bid assignment, each source and demand at each point of interest is limited to one machine unit, person or place.

In general (Yamit, 2015) the steps in the Hungarian Method according to Yamit (2015) are, (1) compiling a time / cost table, (2) doing column reductions, (3) doing line deductions, (4) forming optimum assignments, (5) revising table, and (6) determines optimum assignment. The assignment model will be used to determine the completion time of the sewing line area in the company engaged in the garment industry. The main problem of the company is that it has not determined its assignment per line, namely the system 1 resource (line) is equal to 1 job. This has an impact on the time of completion of work and has an impact on achieving unattainable production targets.

The data taken were the completion time of the work used by each employee to sew each type of clothing. This research was conducted in the sewing line area, where this area consists of three lines, namely Line 1, Line 2 and Line 3 and the products produced are Dresses, Inners, and Tunics. The time for completion of work, before using the Hungarian method, can be seen in table 1.

Table 1: Work Settlement time every type produvt (hours)

Area	**Types of Products**	**EMPLOYEES**								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**I**	**J**
Line 1	Dress	4	3	5	5	3	4	2	3	3
	Inner	3	5	4	3	6	5	3	4	6
	Tunik	6	7	7	6	5	5	6	6	6
Line 2	Dress	3	3	4	4	5	4	3	3	4
	Inner	5	5	6	4	4	5	8	4	6
	Tunik	7	7	7	6	6	7	6	5	5
Line 3	Dress	4	3	4	4	5	3	5	4	4
	Inner	5	4	3	5	5	3	2	5	5
	Tunik	7	5	6	6	5	7	6	7	7

The time for completing work before using the Hungarian method can be seen from the average completion time of each job (Table 2).

Table 2: Minimum settlement time before using the Hungarian method

Area	**Types of Products**	**Time (hours)**
Line 1	Dress	3,6
	Inner	4,3
	Tunik	6,0
Line 2	Dress	3,7
	Inner	5,2
	Tunik	6,2
Line 3	Dress	4,0
	Inner	4,1
	Tunik	6,2
Total Minimum Time		43,4

Based on Table 1, to solve the optimization of the assignment problem, the problem is formulated into linear programming first and the following equation is obtained:

$$\text{Min } Z = \sum_{i=1}^{9} \sum_{j=1}^{9} C_{ij} X_{ij} \qquad (3)$$

With constraints :

$$\sum_{i=1}^{9} X_{ij} = \sum_{j=1}^{9} X_{ij} = 1 \qquad (4)$$

$X_{ij} \geq 0$ and C_{ij} is a known constant.

By Z expressing the total time to complete the work and Cij is the time it takes the employee to complete the job and based on the above equation it can be formulated into linear programming as follows:

$$Z = 4X_{11}+3X_{12}+5X_{13}+5X_{14}+3X_{15}+4X_{16}+2X_{17}+3X_{18}+3X_{19} +3X_{21}+5X_{22}+4X_{23}+3X_{24}+6X_{25}+5X_{26}+3X_{27}+4X_{28}+6X_{29}+6X_{31}+7X_{32}+7X_{33}+6X_{34}+5X_{35}+5X_{36}+6X_{37}+6X_{38}+6X_{39}+3X_{41}+3X_{42}+4X_{43}+4X_{44}+5X_{45}+4X_{46}+3X_{47}+3X_{48}+4X_{49}+5X_{51}+5X_{52}+6X_{53}+4X_{54}+4X_{55}+5X_{56}+8X_{57}+4X_{58}+6X_{59}+7X_{61}+7X_{62}+7X_{63}+6X_{64}+6X_{65}+7X_{66}+6X_{67}+5X_{68}+5X_{69}+4X_{71}+3X_{72}+4X_{73}+4X_{74}+5X_{75}+3X_{76}+5X_{77}+4X_{78}+4X_{79}+5X_{81}+4X_{28}+3X_{83}+5X_{84}+5X_{85} +3X_{86}+2X_{87}+5X_{88}+5X_{89}+7X_{91}+5X_{92}+6X_{93}+6X_{94}+5X_{95}+7X_{96}+6X_{97}+7X_{98}+7X_{99} \qquad (5)$$

With Z expressing the total time to complete the work and Cij is the time it takes the employee to complete the job and based on the above equation it can be formulated into linear programming as follows: determine the smallest entry of each row; the time matrix for this problem is a 9x9 matrix.

Table 3: The Smallest Entry of Every time of completion of work for every type of products (hours)

Area	**Types of Products**	**EMPLOYEES**								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**I**	**J**
Line 1	Dress	4	3	5	5	3	4	2	3	3
	Inner	3	5	4	3	6	5	3	4	6
	Tunik	6	7	7	6	5	5	6	6	6
Line 2	Dress	3	3	4	4	5	4	3	3	4
	Inner	5	5	6	4	4	5	8	4	6
	Tunik	7	7	7	6	6	7	6	5	5
Line 3	Dress	4	3	4	4	5	3	5	4	4
	Inner	5	4	3	5	5	3	2	5	5
	Tunik	7	5	6	6	5	7	6	7	7

The next step subtracts all entries in the row with the smallest entries, the results are shown in table 4 below:

Table 4: Result from the smallest time of every line

Area	Types of Products	EMPLOYEES								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**I**	**J**
Line 1	Dress	2	1	3	3	1	2	0	1	1
	Inner	0	2	1	0	3	2	0	1	3
	Tunik	1	2	2	1	0	0	1	1	1
Line 2	Dress	0	0	1	1	2	1	0	0	1
	Inner	1	1	2	0	0	1	4	0	2
	Tunik	2	2	2	1	1	2	1	0	0
Line 3	Dress	1	0	1	1	2	0	2	1	1
	Inner	3	2	1	3	3	1	0	3	3
	Tunik	2	0	1	1	0	2	1	2	2

The next step ensures that all rows and columns have zero values. And it turns out that in this case there are still clashes or there are still columns that do not yet have zeros, namely column 3. Thus, the smallest value in the column is needed to be used to reduce all the values in the column. After subtracting from column 3, each column and row has zero entries.

Table 5: Zero Value has been in every line and column

Area	Types of Products	Employees								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**I**	**J**
Line 1	Dress	2	1	2	3	1	2	0	1	1
	Inner	0	2	0	0	3	2	0	1	3
	Tunik	1	2	1	1	0	0	1	1	1
Line 2	Dress	0	0	0	1	2	1	0	0	1
	Inner	1	1	1	0	0	1	4	0	2
	Tunik	2	2	1	1	1	2	1	0	0
Line 3	Dress	1	0	0	1	2	0	2	1	1
	Inner	3	2	0	3	3	1	0	3	3
	Tunik	2	0	0	1	0	2	1	2	2

Closing all zero values using minimum vertical / horizontal lines. If the number of lines is the same as the number of rows / columns, then the assignment is optimal. If the number of lines is not the same as the number of rows or columns, then proceed to the next step.

Table 6: Closing all zero values using a vertical/horizontal line

Area	Types of Products	EMPLOYEES								
		A	B	C	D	E	F	G	I	J
Line 1	Dress	2	1	2	3	1	2	0	1	1
	Inner	0	2	0	0	3	2	0	1	3
	Tunik	1	2	1	1	0	0	1	1	1
Line 2	Dress	0	0	0	1	2	1	0	0	1
	Inner	1	1	1	0	0	1	4	0	2
	Tunik	2	2	1	1	1	2	1	0	0
Line 3	Dress	1	0	0	1	2	0	2	1	1
	Inner	3	2	0	3	3	1	0	3	3
	Tunik	2	0	0	1	0	2	1	2	2

Step 4 shows that the number of lines covering all 0 entries is the same as the number of rows/columns, so the assignment is optimal. Because the number of rows/columns in table 4 is the same, then the assignment can be said to be optimal so that the assignment can be done by starting from the row/column which has only one value of 0.
The solution / decision obtained is:

$$X_{17} = X_{21} = X_{36} = X_{48} = X_{54} = X_{69} = X_{72} = X_{83} = X_{95} = 1$$

By adjusting the outcome variables, then the total time (minimum) obtained to complete the work is:

$$Z = X_{17} + X_{21} + X_{36} + X_{48} + X_{54} + X_{69} + X_{72} + X_{83} + X_{95}$$

$$= 2 + 3 + 5 + 3 + 4 + 5 + 3 + 3 + 7 = 35 \text{ hours}$$

Based on the calculation results using the Hungarian method, the optimal total work completion time is 35 hours, with the assignment settings as follows:

Table 7: Total optimal time using the Hungarian method

Area	Types of Products	Employees	Waktu (Jam)
Line 1	Dress	A	2
	Inner	B	3
	Tunik	C	5
Line 2	Dress	D	3
	Inner	E	4
	Tunik	F	5
Line 3	Dress	G	3
	Inner	H	3
	Tunik	I	7

Total Waktu Optimal	35

The results of processing data in table 7 show that by applying the Assignment Method, the completion time of work in the garment industry company can be completed with a time of 35 hours, meaning there is a savings of 8.3 hours compared to before using the Hungarian method.

Conclusion

Based on the observations of researchers, the company has not implemented assignments based on 1 resource equal to 1 job. This causes a delay in the completion of work which results in an increase in the amount of overtime from each employee (operator) while production targets are also not achieved.

The calculation results before using the Hungarian method obtained work completion time for garment industry companies at 43.3 hours, while after using the Hungarian method the work completion time was 35.0 hours. This means the time efficiency was 8.3 hours compared to the time before using the Hungarian Method.

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