

Analysis of labor employment assessment on production machine to minimize time production

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Abstract. Every company both in the field of service and manufacturing always trying to pass efficiency of it's resource use. One resource that has an important role is labor. Labor has different efficiency levels for different jobs anyway. Problems related to the optimal allocation of labor that has different levels of efficiency for different jobs are called assignment problems, which is a special case of linear programming. In this research, Analysis of Labor Employment Assesment on Production Machine to Minimize Time Production, in PT PDM is done by using *Hungarian* algorithm. The aim of the research is to get the assignment of optimal labor on production machine to minimize time production. The results showed that the assignment of existing labor is not suitable because the time of completion of the assignment is longer than the assignment by using the *Hungarian* algorithm. By applying the *Hungarian* algorithm obtained time savings of 16%.

1. Introduction

Efficient use of resources within a company is absolutely do. One of the most important resource is labor. Companies must be able to put their own labor in the right position. The problem is how to put the labor in the right position? This research tries to solve the problem of assignment with *Hungarian* algorithm The aim of the research is to get the assignment of optimal labor on production machine to minimize time production. The *Hungarian* algorithm deals with the optimal allocation of various productive resources, especially for labor who has different efficiency levels for different jobs anyway.

This problem called assignment problem. This method was first developed by a Hungarian mathematician, D. Konig (T. Hani Handoko, 2000). Assignment problem is one of the transportation problem and can be stated as follows: "With the availability of facilities to carry out the type of jobs in which each facility (machine, person, and energy), the problem is how to determine. which types of work, in order to minimize the amount of sacrifice (money, time and energy)". Assignment problem of it's wider use in the field of management, especially the decision to specify what kind of job must be done. Assignment models aim to allocate "resources" for the same number of "jobs" to the minimum total cost. Assignment is made on the basis that each resource must be assigned only for one job. For an $n \times n$ assignment problem, the number of possible assignment is done equal to $n!$ (n factorial) because of the one-to-one pairing. This assignment model can be used to look for problems of minimization or maximization.



In the assignment problem will be assigned a number of assignment to a number of assignee on a one-to-one basis. In this research, the assignee is the worker and the assignment is the machine (assignment matrix can be seen in Table 1).

Table 1. Assignment Matrix in General

Source	Aim				Capacity/ period
	1	2	...	n	
1	C_{11}	C_{12}		C_{1n}	1
	X_{11}	X_{12}		X_{1n}	
2	C_{21}	C_{22}		C_{2n}	1
	X_{21}	X_{22}		X_{2n}	
.					
m	C_{m1}	C_{m2}		C_{mn}	1
	X_{m1}	X_{m2}		X_{mn}	
Need/ period	1	1		1	

In general, the mathematical model of the assignment problem can be formulated as follows: Minimize (max)

$$Z = \sum_{i=1}^m \sum_{j=1}^n C_{ij} \times X_{ij}$$

Limits :

(1)

$$\sum_{i=1}^m X_{ij} = \sum_{j=1}^n X_{ij} = 1$$

(2)

Information :

Z = total cost or time or profit

C_{ij} = cost or time / unit

X_{ij} = assignment from source i to j

In the settlement, the assignment problem is divided into two, namely maximization and minimization. Accordance with the aim of research then that will be used in this research is the problem of minimization.

Hungarian algorithm procedure for minimization problem in general as follows:

1. The number on each row is subtracted by the smallest number on the row in question, check on the number whose value is zero whether it is optimal or not. It is said to be optimal if zeros exist in different rows and columns, if not optimal then do the same thing but in each column.
2. If step 1 is not optimal yet, then do step 2 by creating a vertical and horizontal line that passes zero, find the smallest number that is not closed by the line.
3. Subtract the smallest number on the unclosed line whose value is not zero yet, and add to the number closed either by vertical or horizontal lines. Check whether it is optimal or not.
4. If not optimal yet, then step 3 needs to be repeated steadily until the result is optimal.

2. Methodology

The research methodology can be seen in Figure 1. The data needed in solving the problem in this research is the data of five labors who will be assigned to five production machines, including time measurement data for each labor in operating the machine. Continued with the test data sufficiency. Data is said to be sufficient when the required measurement (N') is exceeded by the number of measurements performed (N) [6]. With 95% confidence level and 10% accuracy calculated by the formula:

$$N' = \left[\frac{40\sqrt{N \sum x_i^2 - (\sum x_i)^2}}{\sum x_i} \right]^2 \quad (3)$$

Where: x_i = time observation data

After the data is sufficient, then do the test data uniformity, then determined the standard time of each labor on each production machine, the results can be seen in Table 2. Further optimization done with *Hungarian* algorithm.

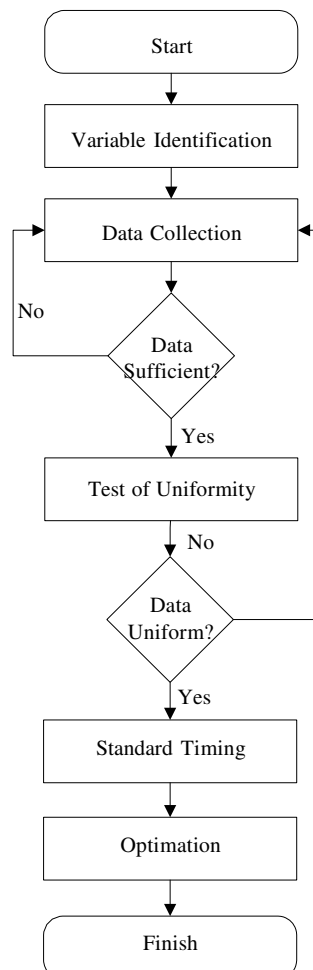


Figure 1. Research Stages

3. Result and Discussion

The results of data collection of the assignment of five labor on the five production machines can be seen in Table 2. From Table 2 it can be seen that prior to labor optimization, if the labor 1 assigned to machine A takes 40 minutes, if assigned to machine B takes 40 minutes, whereas if labor 2 is assigned to machine A takes 30 minutes and so on.

Table 2. Data on The Measurement of Labor Time on The Machine (minutes)

Labor	Machine				
	A	B	C	D	E
1	40	40	50	30	35
2	30	30	45	45	30
3	35	35	36	40	40
4	40	30	40	35	45
5	25	45	48	35	30

After processing data using *Hungarian* algorithm obtained optimal result which is listed in Table 3.

Table 3. Comparison of Assignments Before and After Optimization

Labor	Before		After	
	Machine	Time (minutes)	Machine	Time (minutes)
1	B	40	D	30
2	A	30	E	30
3	D	40	C	36
4	C	40	B	30
5	E	30	A	25
Total Time		180	151	

From Table 3 can be seen the comparison of total work completion time before (180 minutes) and after optimization (151 minutes), so the obtained time efficiency is 16%. To solve the problem above can also be done manually by simplex method. But because the variables are relatively numerous, the use of simplex method is not efficient. To facilitate the settlement can be used computer program that is LINDO (*Linear Interactive Discrete Optimizer*). Completion with LINDO is done by first making a mathematical model formulation of the problem. Formulation mathematical model of the problem:

Function Goals :

$$\text{Minimization } Z = 40X_{1A} + 40X_{1B} + 50X_{1C} + 30X_{1D} + 35X_{1E} + 30X_{2A} + 30X_{2B} + 45X_{2C} + 45X_{2D} + 30X_{2E} + 35X_{3A} + 35X_{3B} + 36X_{3C} + 40X_{3D} + 40X_{3E} + 40X_{4A} + 30X_{4B} + 40X_{4C} + 35X_{4D} + 45X_{4E} + 25X_{5A} + 45X_{5B} + 48X_{5C} + 35X_{5D} + 30X_{5E}$$

Limits :

$$\begin{aligned} X_{1A} + X_{1B} + X_{1C} + X_{1D} + X_{1E} &= 1 \\ X_{2A} + X_{2B} + X_{2C} + X_{2D} + X_{2E} &= 1 \\ X_{3A} + X_{3B} + X_{3C} + X_{3D} + X_{3E} &= 1 \\ X_{4A} + X_{4B} + X_{4C} + X_{4D} + X_{4E} &= 1 \\ X_{5A} + X_{5B} + X_{5C} + X_{5D} + X_{5E} &= 1 \end{aligned}$$

$$\begin{aligned}
 X_{1A} + X_{2A} + X_{3A} + X_{4A} + X_{5A} &= 1 \\
 X_{1B} + X_{2B} + X_{3B} + X_{4B} + X_{5B} &= 1 \\
 X_{1C} + X_{2C} + X_{3C} + X_{4C} + X_{5C} &= 1 \\
 X_{1D} + X_{2D} + X_{3D} + X_{4D} + X_{5D} &= 1 \\
 X_{1E} + X_{2E} + X_{3E} + X_{4E} + X_{5E} &= 1 \\
 X_{ij} &\geq 0 \quad (i = 1, 2, \dots, 5, j = 1, 2, \dots, 5) \\
 X_{ij} &= 0 \text{ or } 1
 \end{aligned}$$

Results of assignment with LINDO can be seen in Table 4.

Table 4. Results of Assignment Using LINDO

LP Optimum Found at Step 12

No. Iterations = 12

Objective Function Value

Ranges In Which The Basis Is Unchanged

1) 151.0000

Objective Coefficient Ranges

Variable	Value	Reduced Cost
X1A	0.000000	15.000000
X1B	0.000000	15.000000
X1C	0.000000	24.000000
X1D	1.000000	0.000000
X1E	0.000000	5.000000
X2A	0.000000	5.000000
X2B	0.000000	5.000000
X2C	0.000000	19.000000
X2D	0.000000	15.000000
X2E	1.000000	0.000000
X3A	0.000000	0.000000
X3B	0.000000	0.000000
X3C	1.000000	0.000000
X3D	0.000000	0.000000
X3E	0.000000	0.000000
X4A	0.000000	10.000000
X4B	1.000000	0.000000
X4C	0.000000	9.000000
X4D	0.000000	0.000000
X4E	0.000000	10.000000
X5A	1.000000	0.000000
X5B	0.000000	20.000000
X5C	0.000000	22.000000
X5D	0.000000	5.000000
X5E	0.000000	0.000000

Current Coef	Allowable Increase	Allowable Decrease
40.000000	Infinity	15.000000
40.000000	Infinity	15.000000
50.000000	Infinity	24.000000
30.000000	5.000000	Infinity
35.000000	Infinity	5.000000
30.000000	Infinity	5.000000
30.000000	Infinity	5.000000
45.000000	Infinity	19.000000
45.000000	Infinity	15.000000
30.000000	5.000000	Infinity
35.000000	0.000000	5.000000
35.000000	5.000000	0.000000
36.000000	9.000000	Infinity
40.000000	0.000000	5.000000
40.000000	Infinity	0.000000
40.000000	Infinity	10.000000
30.000000	0.000000	Infinity
40.000000	Infinity	9.000000
35.000000	Infinity	0.000000
45.000000	Infinity	10.000000
25.000000	5.000000	Infinity
45.000000	Infinity	20.000000
48.000000	Infinity	22.000000
35.000000	Infinity	5.000000
30.000000	0.000000	5.000000

			RIGHTHAND SIDE RANGES		
Row	Slack or Surplus	Dual Price	Current RHS	Allowable Increase	Allowable Decrease
2	0.000000	10.000000	1.000000	0.000000	0.000000
3	0.000000	10.000000	1.000000	0.000000	0.000000
4	0.000000	0.000000	1.000000	0.000000	0.000000
5	0.000000	5.000000	1.000000	0.000000	0.000000
6	0.000000	10.000000	1.000000	0.000000	0.000000
7	0.000000	-35.000000	1.000000	0.000000	0.000000
8	0.000000	-35.000000	1.000000	0.000000	0.000000
9	0.000000	-36.000000	1.000000	0.000000	0.000000
10	0.000000	-40.000000	1.000000	0.000000	0.000000
11	0.000000	-40.000000	1.000000	0.000000	0.000000

4. Conclusion

From the results of research conducted can be concluded that the allocation of labor on production machines in the company is not optimal. After optimization using *Hungarian* algorithm can be determined optimal results of assignment, with time savings of 16%.

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