Optimal Bread Production Operator Placement by Using Hungarian Method

Masrul Indrayana [1,*], Jono [1], Ilmardani Rince Ramli [1], Maura Dewani Cristy [1]

1 Fakultas Sains dan Teknologi, Program Studi Teknik Industri, Universitas Widya Mataram

*E-mail: masrul_indrayana@yahoo.com

ABSTRACT

CV Roti Bangkit is a home industry that produces packaged bread with various variations. CV Roti Bangkit is addressed in Kadisono, Tegaltirto, Berbah District, Sleman Regency, Special Region of Yogyakarta. Operator placement is done randomly in the manufacturing of oval cheese so that production targets are often not achieved. Therefore it's necessary to look at the position of operators.The problem of optimal operator placement can be done using the Hungarian method. Time data for each operator is measured for each work element, and the standard time is calculated. After receiving the most optimal operator placement, we can calculate the increased productivity before and after applying the assignment method. Based on this research, the standard operator time before applying the assignment method is 90.96 seconds, and after using the assignment method is 75.41 seconds. The level of productivity based on standard output calculations before and after the application of the assignment method increases productivity by 27.28%

KEYWORDS

hungarian method; optimal operator placement; productivity

1. INTRODUCTION

Human resources need to increase productivity at work. Poor productivity will cause variation in the output produced. To increase the success of a business, a company must be careful in carrying out the strategy or technique used. The problem that often occurs relates to the optimal allocation of labor. This problem is an assignment problem. The assignment problem starts with placing operators in several fields by determining the optimal time for each operator.

The issue of assigning operators can be done in two ways, namely manually or using software programs. This research searches the time for each operator for each work element, and then the operators' assignment will be allocated using the Hungarian method. The difference between before and after Hungarian implementation is tested with a hypothesis and continued with productivity calculations.

2. METHODOLOGY

The Assignment Method is part of a linear program that allocates job to specific subjects to obtain optimal results. Optimal results can be in the form of the most minimal costs, the maximum benefits, the minimum time, and so on. The analysis tool for this method uses the Hungarian method approach. This method is mutually exclusive, meaning that if someone has done a particular job, it is impossible to do another job (one person, one job).

Problems solved through the assignment method include Maximization problems Concerning issues of profit, sales, satisfaction, minimization problems concerning production costs, travel time, wages, etc (Kuru et al., 2019; Rusdiana et al., 2019; Sari et al., 2021; Son & Kim, 2014). There is also a requirement in the assignment method, namely that the number of rows in the assignment table must be the same as the number of columns (number of rows = number of columns). In other words, the number of operators must equal the number of jobs. An additional variable, namely a dummy, is needed if not equal. The dummy is added to the row or column of the assignment table. The dummy variable shows which jobs are not filled by anyone and operators without a job.

The research was conducted at CV Roti Bangkit, located at Kadisono, Tegaltirto, Berbah, Sleman, Yogyakarta. The research began in December 2021. The data needed in this research are as follows: Cheese oval bread production process, number of operators, number of work elements, Data on working time for each work element for each operator, and Data on standard operator time before and after assignment. Data collection was carried out by interviewing operators of the warehouse and marketing department in the company.

The data collected is then tested for adequacy until the data meet the criteria of $N' < N$. The uniformity of the data is based on calculating the Upper Control Limit (UCL) and the Lower Control Limit (LCL)(Panudju et al., 2021).

3. RESULTS AND DISCUSSION

Work measurements were constructed to obtain standard time data (Lukodono & Ulfa, 2018). Eight operators were assigned to perform eight elements of work. The eight work elements of the oval cheese bread production process are presented in Table 1 below:

Table 1. The Eight Elements of Work

Nu.	Element of Work	Nu.	Element of Work
1	dough cutting (P1)	5	Formation of Bread (P5)
2	dough balancing (P2)	6	Check (P6)
3	dough distribution (P3)	7	Giving Toppings (P7)
4	Baking Pan (P4)	8	Packaging (P8)

The observed data obtained for each work element in the cheese oval bread production process is presented in matrix shown in Table 2. The row section offers the operators and the column for the work elements. Furthermore, the assignment of operators using the Hungarian method is carried out by finding the smallest value of each row and column. The complete results are shown in Table 3 to Table 11.

Table 2. Standard Time Matrix (Sec)

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	19.57	11.36	8.62	7.94	7.11	8.62	12.59	8.76
2	20.26	8.21	7.94	8.62	8.62	8.76	12.18	8.62
3	17.75	7.8	8.6	8.07	6.99	11.97	14.66	8.6
4	18.69	7.8	10.08	6.99	8.47	12.24	16.68	11.03
5	21.14	9.91	10.04	8.45	7.92	10.83	18.63	9.77
6	22.26	8.51	9.03	7.59	8.51	9.95	14.66	9.29
7	20.95	9.03	9.82	8.38	6.8	7.59	17.67	9.03
8	20.16	9.03	9.29	8.11	7.59	8.38	16.63	7.59

Look for the smallest value of each row in Table 2, then all values of each row are subtracted to the smallest value. The results of the calculation are presented in Table 3.

Table 3. Reduced Matrix (Sec)

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	12.46	4.25	1.51	0.83	0	1.51	5.48	1.65
2	12.32	0.27	0	0.68	0.68	0.82	4.24	0.68
3	10.76	0.81	1.61	1.08	0	4.98	7.67	1.61
4	11.7	0.81	3.09	0	1.48	5.25	9.69	4.04
5	13.22	1.99	2.12	0.53	0	2.91	10.71	1.85
6	14.67	0.92	1.44	0	0.92	2.36	7.07	1.7
7	14.15	2.23	3.02	1.58	0	0.79	10.87	2.23
8	12.57	1.44	1.7	0.52	0	0.79	9.04	0

From Table 3, each row has a value of 0 (zero), but each column still needs to have a value of 0 (zero) as the same method is carried out for columns. Look for the smallest value from each column and subtract all with the smallest value from each column. The complete results are presented in Table 4.

Table 4. Total Opportunity Time Matrix (Sec)

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1.7	3.98	1.51	0.83	0	0.72	1.24	1.65
2	1.56	0	0	0.68	0.68	0.03	0	0.68
3	0	0.54	1.61	1.08	0	4.19	3.43	1.61
4	0.94	0.54	3.09	0	1.48	4.46	5.45	4.04
5	2.46	1.72	2.12	0.53	0	2.12	6.47	1.85
6	3.91	0.65	1.44	0	0.92	1.57	2.83	1.7
7	3.39	1.96	3.02	1.58	0	0	6.63	2.23
8	1.81	1.17	1.7	0.52	0	0	4.8	0

Table 4 shows a value of 0 (zero) for each row and column. Next, draw lines horizontally and vertically that cover all 0 (zero) values. To get the minimum possible lines, draw a line in the row or column with the highest 0 (zero) value first. The number of lines must equal the number of rows or columns, namely 8. If the number of lines differs from the number of rows or columns, then the table is not optimal. Then the same calculation process is carried out as shown in Table 5 to Table 11 below:

Table 5. Optimality Test **1**

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1.7	3.98	1.51	0.83	0	0.72	1.24	1.65
2	1.56	0	0	0.68	0.68	0.03	0	0.68
3	0	0.54	1.61	1.08	0	4.19	3.43	1.61
4	0.94	0.54	3.09	0	1.48	4.46	5.45	4.04
5	2.46	1.72	2.12	0.53	0	2.12	6.47	1.85
6	3.91	0.65	1.44	0	0.92	1.57	2.83	1.7
7	3.39	1.96	3.02	1.58	0	0	6.63	2.23
8	1.81	1.17	1.7	0.52	0	0	4.8	0

Table 6. Optimality Test **2**

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1.7	3.44	0.97	0.83	0	0.18	0.7	1.11
2	2.1	0	0	1.22	1.22	0.03	0	0.68
3	0	0	1.07	1.08	0	3.65	2.89	1.07
4	0.94	0	2.55	0	1.48	3.92	4.91	3.5
5	2.46	1.18	1.58	0.53	0	1.58	5.93	1.31
6	3.91	0.11	0.9	0	0.92	1.03	2.29	1.16
7	3.93	1.96	3.02	2.12	0.54	0	6.63	2.23
8	2.35	1.17	1.7	1.06	0.54	0	4.8	0

Table 7. Optimality Test **3**

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1.7	3.44	0.97	0.83	0	0.18	0.7	1.11
2	2.1	0	0	1.22	1.22	0.03	0	0.68
3	0	0	1.07	1.08	0	3.65	2.89	1.07
4	0.94	0	2.55	0	1.48	3.92	4.91	3.5
5	2.46	1.18	1.58	0.53	0	1.58	5.93	1.31
6	3.91	0.11	0.9	0	0.92	1.03	2.29	1.16
7	3.93	1.96	3.02	2.12	0.54	0	6.63	2.23
8	2.35	1.17	1.7	1.06	0.54	0	4.8	0

Table 8. Optimality Test **4**

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1.59	3.33	0.86	0.83	0	0.18	0.59	1.11
2	2.1	0	0	1.33	1.33	0.14	0	0.79
3	0	0	1.07	1.19	0.11	3.76	2.89	1.18
4	0.94	0	2.55	0.11	1.59	4.03	4.91	3.61
5	2.35	1.07	1.47	0.53	0	1.58	5.82	1.31
6	3.8	0	0.79	0	0.92	1.03	2.18	1.16
7	3.82	1.85	2.91	2.12	0.54	0	6.52	2.23
8	2.24	1.06	1.59	1.17	0.65	0.11	4.69	0

Table 9. Optimality Test **5**

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1.59	3.33	0.86	0.83	0	0.18	0.59	1.11
2	2.1	0	0	1.33	1.33	0.14	0	0.79
3	0	0	1.07	1.19	0.11	3.76	2.89	1.18
4	0.94	0	2.55	0.11	1.59	4.03	4.91	3.61
5	2.35	1.07	1.47	0.53	0	1.58	5.82	1.31
6	3.8	0	0.79	0	0.92	1.03	2.18	1.16
7	3.82	1.85	2.91	2.12	0.54	0	6.52	2.23
8	2.24	1.06	1.59	1.17	0.65	0.11	4.69	0

Table 10. Optimality Test **6**

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1	3.33	0.27	0.83	0	0.18	0	0.52
2	2.1	0.59	0	1.92	1.92	0.73	0	0.79
3	0	0.59	1.07	1.78	0.7	4.35	2.89	1.18
4	0.35	0	1.96	0.11	1.59	4.03	4.32	3.02
5	1.76	1.07	0.88	0.53	0	1.58	5.23	0.72
6	3.21	0	0.2	0	0.92	1.03	1.59	1.57
7	3.23	1.85	2.32	2.12	0.54	0	5.93	1.64
8	2.24	1.65	1.11	1.76	1.24	0.7	4.69	0

Table 11. Optimality Test **7**

Job Operator	P1	P2	P3	P4	P5	P6	P7	P8
1	1	3.33	0.27	0.83	0	0.18	0	0.52
2	2.1	0.59	0	1.92	1.92	0.73	0	0.79
3	0	0.59	1.07	1.78	0.7	4.35	2.89	1.18
4	0.35	0	1.96	0.11	1.59	4.03	4.32	3.02
5	1.76	1.07	0.88	0.53	0	1.58	5.23	0.72
6	3.21	0	0.2	0	0.92	1.03	1.59	1.57
7	3.23	1.35	2.32	2.12	0.54	0	5.93	1.64
8	2.24	1.65	1.11	1.76	1.24	0.7	4.69	0

Table 11 has obtained lines whose number equals the number of rows or columns, so the table is optimal. Then determine the assignment of each operator by selecting a row or column with a value of 0 (zero). From the assignment results using the Hungarian method, a trial was carried out by placing the operator back in the appropriate work element. Data adequacy and uniformity tests were then carried out for cycle time, normal time, and standard time. A comparison of the operator standard time before and after the assignment is shown in Table 12.

Table 12. Operator Standard Time Before and After Assignment

Element of Work	Operator	Initial Standard Time (sec)	Operator	Final Standard Time (sec)
dough cutting (P1)	6	14.66	1	11.65
dough balancing (P2)	2	10.08	2	7.8
dough distribution (P3)	4	22.26	3	17.38
Baking Pan (P4)	7	11.36	4	7.94
Formation of Bread (P5)	5	7.92	5	7.66
Check (P6)	3	8.38	6	7.8
Giving Toppings (P7)	1	8.71	7	7.59
Packaging (P8)	8	7.59	8	7.59
Total Waktu Proses		**90.96**		**75.41**

1. DISCUSSION OF FINDING

From the data obtained, a hypothesis test was carried out using the SPSS-21 computer program with the Paired-Samples T Test menu. The results show the significance of the test, namely that the value is 0.016 <0.050, which means H0 is rejected so that the standard time before and after the assignment is different. Increased productivity can be affected by the level of production or production standards. After repairing the assignment, we can calculate the new productivity. The increased productivity level can be calculated by comparing the improved standard output with the initial. For some related data, such as standard time data, operator working hours, and initial standard output, it is essential to calculate the standard production output that the company must achieve to increase productivity, as calculated below:

– ***Standard Output (SO) for Initial***

Calculation of the standard output of all elements of works from Table 5.13(Lukodono & Ulfa, 2018):

a. SO/hours = 1 hrs/90.96 sec = 1/1.51 minute = 1/0.025 hrs = 40 units/hours
b. SO/day = 7 hrs × 40 = 280 units/day
c. SO/week = 6 days × 280 = 1,680 units/week
d. SO/month = 26 days × 1,680 = 43,680 units/month

From the calculation of the initial standard output of the entire production process, the total production output of oval cheese bread is 43,680 units/month.

– ***Standard Output (SO) for Final***

Calculation of the standard output of all elements of works from Table 5.13 (Lukodono & Ulfa, 2018):

a. SO/hours = 1 hrs/75.41sec = 1/1.25 minute = 1/0.020 hrs = 50 units/hours
b. SO/day = 7 hrs × 50 = 350 units/day
c. SO/week = 6 days × 350 = 2,100 units/week
d. SO/month = 26 days × 2,100 = 55,600 units/month

From the calculation of the final standard output of the entire production process, the total production output of oval cheese bread is 55,600 units/month.

– **Calculation of Productivity Index**

Calculating the Productivity Index according to (Muhartono et al., 2020; Ramadhan & Waluyo, 2020)as below:

$$\mathrm{IP} = \frac{\mathrm{OS}_1 - \mathrm{OS}_0}{\mathrm{OS}_0} \times 100\%$$

$$\mathrm{IP} = \frac{55600 - 43680}{43680} \times 100\%$$

$$\mathrm{IP} = \frac{11920}{43680} \times 100\%$$

$$\mathrm{IP} = 27.28\ \%$$

The percentage increase in productivity is 27.28%, equivalent to 11,920 units/month. From the data obtained, the productivity level has improved, and the company's production capacity is increased.

4. CONCLUSION

Based on the discussion from the study, the results obtained that the optimal placement of cheese oval bread production operators for each work element is operator 1 for the topping assignment with a standard time of 12.59 seconds, operator 2 for the dough distribution task with a standard time of 7.59 seconds, operator 3 for the dough cutting with a standard time of 17.75 seconds, operator 4 for the dough distribution with a standard time of 7.80 seconds, operator 5 for the bread forming with a standard time of 7.92 seconds, operator 6 for the task of basting the pan with a standard time of 7.59 seconds, operator 7 for checking with a standard time of 7.59 seconds, and operator 8 for the task of packing with a standard time of 7.59 seconds. The reassignment of operators at CV Roti Bangkit using the Hungarian method has increased productivity by 27.28%, or 11,920 units/month. Production output increased from 43,680 units/month to 55,600 units/month.

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