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Application of Blocplan and Aldep Algorithms for Optimizing Production Layout at Meatball Factory

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ABSTRACT

Layout is an element that must be considered in industrial design. A layout that considers the distance and proximity of departments will have better productivity. Facts on the ground show that there are still many industries that have not paid attention to this, one of which is the Meatball Manufacturing Factory, Brenggolo Street, Kediri. The purpose of this study is to minimize material handling costs while increasing productivity through improved design of meatball production facilities, analyze the sensitivity of layout changes, and compare the efficiency of the Blocplan algorithm and the Aldep algorithm in solving problems in meatball production by considering uncertainty. The method used in this study uses the Blocplan and Aldep algorithms, added with sensitivity analysis through several scenarios. The results showed that Blocplan and Aldep were able to provide recommendations for improving the layout of the meatball manufacturing factory's production facilities with good flow and efficient operational costs. Blocplan produces a cost of Rp. 1,366,761.6 or save 13.6% of the actual layout. While Aldep generates a cost of Rp. 797,040 or save 49.6% of the actual layout. In the sensitivity and Monte Carlo analysis, it was found that Aldep has the potential for future projection and has a near-perfect positive probability compared to Blocplan. This shows that the Aldep approach is a good and recommended layout proposal for the company.

Keywords: *Aldep; Blocplan; Layout; Material Handling Cost, Sensitivity*

Introduction

Facility layout is an important element in the sustainability of an industry as it relates to operations, flexibility, and productivity. Proper layout placement will increase industrial productivity while minimising costs incurred. Ed. [1]. Meanwhile, poor layout placement will lead to decreased productivity and increased costs incurred. ed. [2]. According to Kareem et al., 15%-75% of an industry's production operating costs are material handling costs [3]. Therefore, material handling is an important thing to consider in minimizing the costs incurred in an industrial operation.on [4]. One of the industries that requires a layout solution is a meatball factory located on Brenggolo Street, Kediri.

The meatball factory, located on Brenggolo Street, Kediri, is one of the largest meatball producers in Kediri Regency. However, based on facts in the field, it was found that the existing factory layout was not well structured. Baladraf et al. state that facility layout problems are classified as complex problems related to distance and proximity between departments, so that they cannot be solved in a short time, or commonly referred to as hard, non-polynomial [5]. A special approach is needed using constructive and corrective algorithms to create an optimal layout. [6]. There are quite a few algorithms used to solve layout problems, including systematic layout planning, craft, blocplan, and aldep [7][8][9]. Two algorithms that are often used and proven effective are Blocplan and Aldep. [10][11].

The Blocplan algorithm is a layout improvement system that considers the proximity of a department while finding the minimum total distance for material movement [12]. In its application, the Blocplan algorithm will provide alternatives based on three main criteria, namely proximity score, product move, and R-score [13]. The proximity score is the weight of the relationship between departments. Product movement is the distance moved from one department to another. Meanwhile, R-score is the value of layout efficiency [14]. At the same time, the Aldep algorithm is one of the layout methods that has almost the same function as Blocplan, which aims to obtain the best layout by considering the closeness of the relationship between departments, so that the most efficient material handling costs are obtained [15]. Blocplan and Aldep algorithms have been used in various agroindustries and successfully created more efficient layouts in terms of total distance and movement time [16][17]. Saifurrahman et al.'s research used the Aldep algorithm in a chocolate-based food industry and succeeded in making layout efficiency by 23% compared to the previous layout [18]. Research by Robecca et al. used the Blocplan approach in the small and medium scale bread-making industry and succeeded in increasing the efficiency of movement and costs by 17% [19]. Puspita et al. also used the Blocplan algorithm for layout evaluation in the packaging manufacturing industry, especially paper and plastic packaging used for food ingredients. The results showed that the Blocplan approach was able to produce an efficiency of 55% and a benefit-cost ratio of 9.47 [20].

Based on previous research in the use of Blocplan and Aldep, the algorithms are still implemented statically and not dynamically, so they have not considered the sensitivity of the new layout. Consideration of changes in future expansion scenarios is an important point for future research. The purpose of this study is to minimize material handling costs while increasing productivity through improved design of meatball production facilities, analyze the sensitivity of layout changes, and compare the efficiency of the Blocplan algorithm and the Aldep algorithm in solving problems in meatball production by considering uncertainty.

Research Methods

In this research, several stages are passed to solve the problems faced at the meatball production factory. These stages include problem identification, determining research objectives, data collection in industry, data processing using the bloc plan algorithm and the Alder algorithm, and analysis and evaluation. A complete flowchart of the stages of this research can be seen in Figure 1.

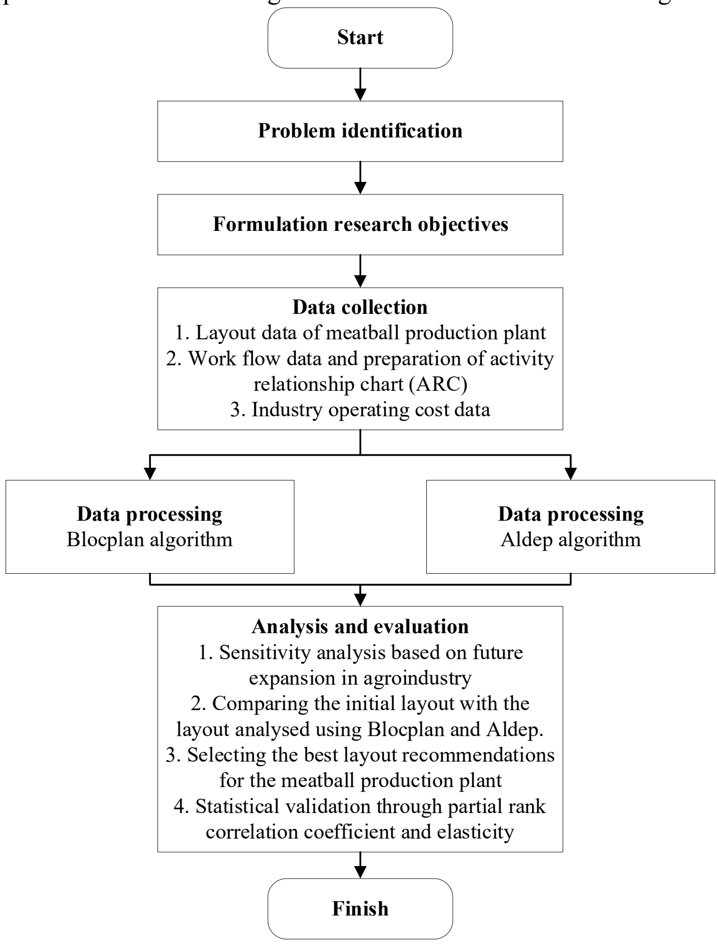

Figure 1. Flowchart of Research Stages

Data collection was carried out through direct observation at the research location with the help of measuring instruments. In addition, data collection was also carried out through interviews with employees of the meatball production factory. The data used includes meatball production plant layout data, workflow data, department proximity data, and factory operating cost data. The data that has been obtained is then processed using several software programs, including Sketchup, Visio, Blocplan, and Aldep. SketchUp is used to sketch the factory layout. Visio is used to compile relationships between departments through activity relationship charts (ARC). At the same time, Blocplan and Aldep are used to simulate the layout and provide recommendations by entering data in the form of the number of departments, the size of each department, and the level of proximity of the departments. The layout details that have been arranged are then analyzed for sensitivity to determine the resilience of the recommended layout. Sensitivity analysis was conducted using Jupyter Notebook through a Monte Carlo Simulation. The results of the Monte Carlo analysis were then statistically tested through partial rank correlation coefficient and elasticity analysis to validate the cost savings results obtained.

Results and Discussion

Current Layout Conditions and Department Information

The meatball manufacturing plant consists of eight departments and is built on an area 26 metres long and 16 metres wide. Visually, the layout condition of this meatball manufacturing plant is presented in Figure 2.

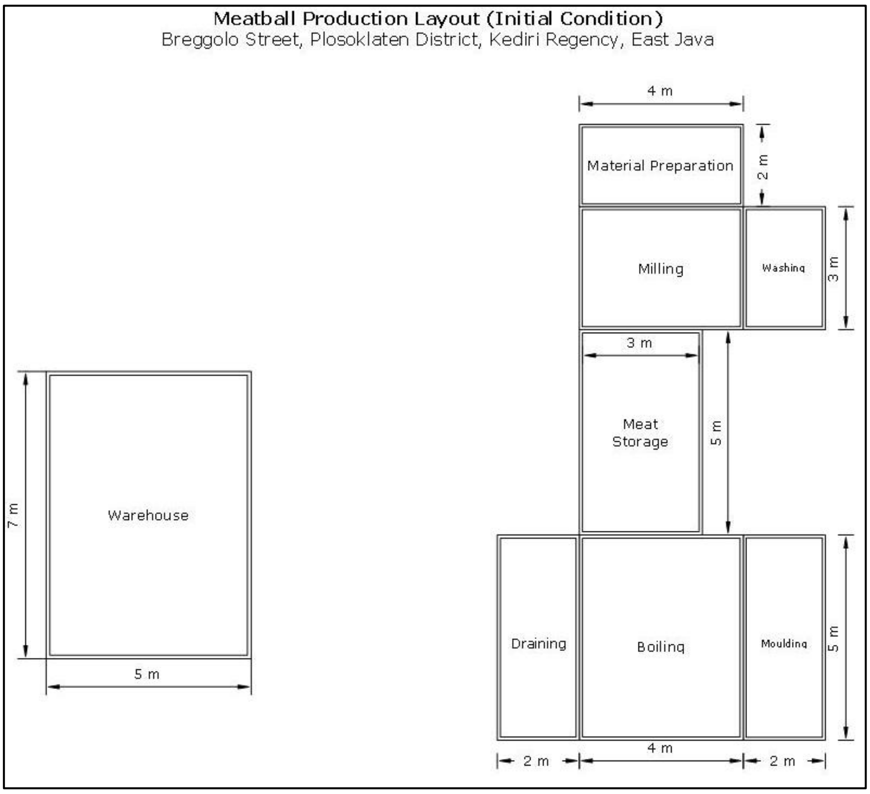

Figure 2. Initial Layout of Meatball Production Plant

Based on the observations presented above, at first glance, the existing layout still does not consider the element of proximity between departments. This causes swelling of the existing material handling costs. [18][19]To find out more details about this, the distance between departments is calculated using the rectilinear / Manhattan distance formula. [23]. The rectilinear/Manhattan distance formula is presented as follows.

$$dij = |xi - xj| + |yi - yj| \quad (1)$$

The detailed explanation of the distance between departments, the frequency of movements that arise, and the material handling costs created are presented in Tables 1 and 2.

Table 1. Department Information

Department	Code	Area
Meat Storage	A	15 m^2
Washing	B	6 m^2
Material Preparation	C	8 m^2
Milling	D	12m^2

Moulding	E	10 m^2
Boiling	F	20 m^2
Draining	G	10 m^2
Warehouse	H	35m^2

Table 2. Distance Between Departments and Material Handling Costs: Initial Condition

Flow	Distance	Frequency	Total Distance	OMH/m	Total OMH
A → B	6 m	8	48 m	129,6	Rp. 6.220
B → C	5,5 m	8	44 m	129,6	Rp. 5.702,4
C → D	2,5 m	8	20 m	129,6	Rp. 2.592
D → E	11 m	16	176 m	129,6	Rp. 22.809,6
E → F	3 m	16	48 m	129,6	Rp. 6.220,8
F → G	3 m	24	72 m	129,6	Rp. 9.331,2
G → H	10 m	8	80 m	129,6	Rp. 10.368
Total (per day)					Rp. 63.244,8
Total (25 workdays)					Rp. 1.581.120

Preparation of Activity Relationship Chart (ARC)

The Activity Relationship Chart is prepared by analysing the closeness between departments in the meatball-making factory. The level of closeness between departments is assessed based on interdepartmental linkages, material flow, and workflow. [24][25]. The Activity Relationship Chart of the meatball manufacturing plant is presented in Figure 3.

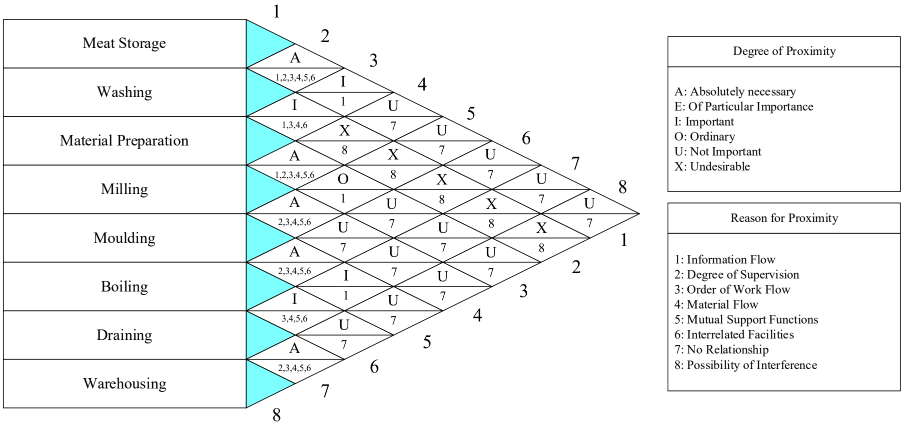

Figure 3. Activity Relationship Chart of Meatball Manufacturing Plant

Data Processing Using Blocplan Algorithm

Data processing using Blocplan is done using software through iteration 15 times to get the most optimal results. The inputs used in data processing include the area of each department and the level of closeness between departments based on the Activity Relationship Chart. Based on the existing data, the Blocplan algorithm will produce an R-score. The highest R-Score is considered the best and optimal layout. The results of the Blocplan algorithm in the form of R-Score, distance between departments, frequency of movement, and material handling costs are presented in Tables 3 and 4.

Table 3. Blocplan Algorithm Data Processing Results

Iteration	Adj. Score	R-Score	Rel. Dist.. Score
1	0,80	0,67	224
2	0,79	0,68	272
3	1,00	0,57	304
4	0,97	0,82	202
5	0,79	0,57	404
6	0,79	0,57	404
7	0,90	0,81	201
8	0,87	0,72	289
9	0,80	0,64	287
10	0,97	0,77	246

11	0,87	0,77	201
12	0,92	0,83	183
13	0,87	0,73	292
14	0,83	0,77	264
15	0,97	0,83	227

Table 4. Distance Between Departments, Material Handling Costs, Blocplan Algorithm

Flow	Distance	Frequency	Total Distance	Cost/m	Total Cost
A → B	4,66 m	8	37,28 m	129,6	Rp. 4.831,5
B → C	2,25 m	8	18 m	129,6	Rp. 2.332,8
C → D	3,23 m	8	25,84 m	129,6	Rp. 3.348,9
D → E	6,95 m	16	111,2 m	129,6	Rp. 14.411,5
E → F	2,8 m	16	44,8 m	129,6	Rp. 5.806,1
F → G	6,3 m	24	151,2 m	129,6	Rp. 19.595,5
G → H	4,19 m	8	33,52 m	129,6	Rp. 4.344,2
Total (per day)					Rp. 54.670,5
Total (25 workdays)					Rp. 1.366.761,6

Based on the results of the layout redesign that has been carried out using the Blocplan algorithm, a moving moment of 421.84 m/month and a cost of 1,366,761/month are obtained. The resulting moving moments and cost show more efficient results compared to the initial layout of the meatball making factory, and managed to save 13.6% of % cost. This can happen because the proposed Blocplan layout provides an organised workflow by considering the proximity between departments. According to Guan et al., A layout that is arranged coherently based on the proximity of departmental relationships will have a positive impact because it is more efficient. [26][27]. The proposed Blocplan layout using Blocplan is presented in Figure 4.

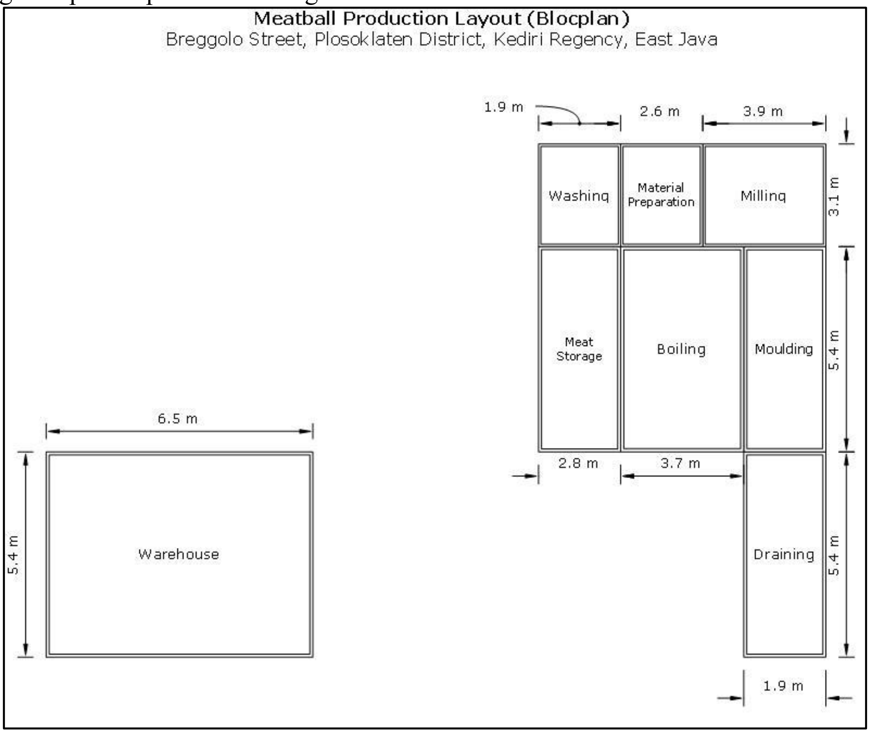

Figure 4. Blocplan Layout of Meatball Production Plant

According to the layout above, the flow of material becomes more efficient. Cost and movement efficiency are two of the things expected from the evaluation and design of layouts, especially in the food industry. An efficient layout can contribute to reducing production cycle time, idle time, bottleneck, or material handling time, and can increase production output [28]. Cost and motion savings in the food. Industry is crucial as it relates to production efficiency. Daya et al. optimized the distance of material movement using the Blocplan approach in a micro, small, and medium enterprise that produces bread.

Blocplan succeeded in improving the efficiency of material movement by 3.79% [29]. Setiyawan et al. also approached the Blocplan algorithm to design the optimal layout of fried soybean production. They succeeded in creating a more efficient layout proposal design of 52.70% within one year [30].

Data Processing Using the Aldep Algorithm

Data processing using Aldep is done using software through iteration 15 times to get the best results. The inputs used in data processing include the overall area, the area of each department, and the level of closeness between departments based on the Activity Relationship Chart. Based on the existing data, the Aldep algorithm will produce a Total Closeness Rating (TCR). The highest Total Closeness Rating (TCR) is considered the best and optimal layout. The results of the Aldep algorithm in the form of Total Closeness Rating (TCR), distance between departments, frequency of movement, and material handling costs created are presented in Tables 5 and 6.

Table 5. Aldep Algorithm Data Processing Results

Iteration	Layout	TCR
1	1A	816
2	3A	768
3	4A	768
4	5A	816
5	6A	640
6	9A	640
7	10A	648
8	11A	648
9	13A	640
10	14A	768
11	16A	768
12	17A	648
13	20A	640
14	5B	816
15	5C	816

Table 6. Distance Between Departments, Material Handling Cost, Aldep Algorithm

Flow	Distance	Frequency	Total Distance	Cost/m	Total Cost
A → B	1,72 m	8	13,76 m	129.6	Rp. 1.783,3
B → C	1,66 m	8	13,28 m	129.6	Rp. 1.721,1
C → D	1,98 m	8	15,84 m	129.6	Rp. 1.052,9
D → E	1,63 m	16	26,08 m	129.6	Rp. 3.380
E → F	3,10 m	16	49,6 m	129.6	Rp. 6.428,2
F → G	3,27 m	24	78,48 m	129.6	Rp. 10.171
G → H	6,12 m	8	48,96 m	129.6	Rp. 6.345,2
Total (per day)					Rp. 31.881,7
Total (25 workdays)					Rp. 797.040

Based on the results of the layout redesign that has been carried out using the Aldep algorithm, a moving moment of 246 m/month and a cost of 797,040/month are obtained. The resulting moving moment and cost show very efficient results compared to the initial layout of the meatball-making factory or the proposed layout of Blocplan. Based on simulations, Aldep's proposed layout can save 49.6% of % cost. However, Aldep's proposed layout has the disadvantage that it requires significant changes to the building structure. This causes cost overruns at the beginning but has a good impact in the long run. The proposed Aldep layout using Blocplan is presented in Figure 5.

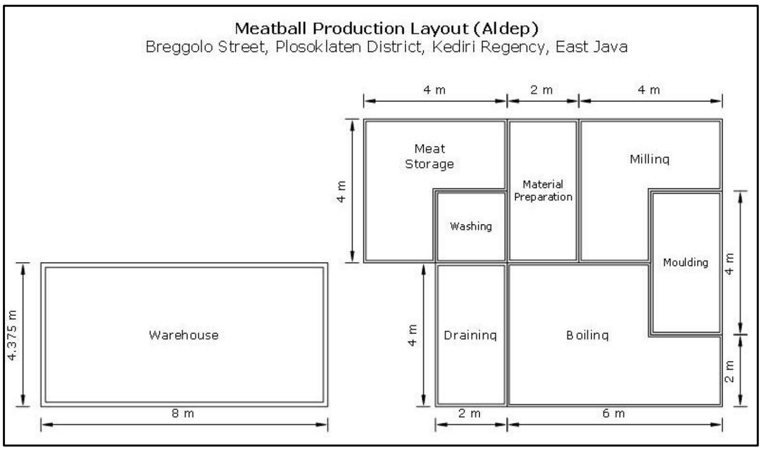

Figure 5. Aldep Layout of Meatball Production Plant

The Aldep approach also provides results that can streamline the distance and cost of material movement. Research by Sonja et al. conducted a factory layout design on noodle making using Aldep as a problem-solving approach. The results show that the Aldep approach has a good proximity score based on the importance of the relationship between departments. [31]. On the other hand, Anam et al., in the frozen food industry, designed a layout proposal that would provide a more efficient material distribution flow. The results showed that a proposed layout with a material flow efficiency of 6.68% was created. [32].

Comparison of Current Conditions, Blocplan Algorithm, and Aldep Algorithm

Based on the research that has been done, a proposed layout using the Blocplan and Aldep algorithms is obtained. The resulting layout is obtained from the redesign of existing departments in the meatball-making factory by considering proximity and workflow. According to Erik and Kuvvetli, material handling costs can be minimised by redesigning the layout so that the material movement created is better and has an ideal distance. [33]. This is because the moment of displacement is directly proportional to the cost spent. A comparison of the current conditions, Blocplan algorithm, and Aldep algorithm is presented in Table 7.

Table 7. Comparison of Current Conditions, Blocplan Algorithm, and Aldep Algorithm

Layout	Cost/month	Cost Savings	Percentage
Initial	Rp. 1.581.120	-	-
Blocplan	Rp. 1.366.761,6	Rp. 214,358.4	13,6%
Aldep	Rp. 797.040	Rp. 784,080	49,6%

The comparison results of the Blocplan and Aldep approaches show good results. Aldep produces more efficient costs than Blocplan, with a difference of Rp. 569,722. Aldep has much better results because, in practice, Aldep has several characteristics that are superior when implemented in the food industry. Aldep has characteristics that are suitable for the food industry because it is ideally applied to production systems that have linear flow and intensive material flow. Aldep also has characteristics that require space efficiency when implemented in industries. [34], [35].

Based on observations made at the. Location and layout changes using Aldep and Blocplan were prepared by considering the realities that exist in the meatball production industry. The findings in the field show that all departments have flexibility in change and are not in the form of a fixed building, so it is possible to adopt the proposed layout. In its application, layout changes using Aldep and Blocplan provide layout changes so that production activity traffic becomes shorter. Results of Shorter production activity traffic have positive implications for the risk of work accidents in an industry. Hashemian and Triantis stated that pressure and intensity in the world of work affect labor safety, increase error rates, and deviant events. [36]. The shorter production activity traffic in terms of frequency also provides benefits for companies in terms of material handling costs, so it has positive implications for production efficiency. In terms of the results obtained, the linearity of the process flow between departments also has an impact on smooth production. A layout that is closer between departments and has a strong degree of closeness will be able to estimate costs because it is able to minimize the distance of the process flow. [37], [38].

Monte Carlo Sensitivity Analysis and Statistical Validation

Testing the resilience and validity of the proposed layouts from Aldep and Blocplan is done through sensitivity analysis and dynamic simulation by considering the uncertainty of future meatball factory expansion projections. In the sensitivity analysis and dynamic simulation, I will use the Monte Carlo approach. In this study, sensitivity analysis and dynamic simulation will be conducted by considering future expansion plans and presenting several scenarios. A sensitivity analysis of meatball production expansion projections is carried out using compound growth factors. In this study, several research expansion projections were applied to both layouts, and several scenarios (5%, 10%, 15%) were used so that the development could be known every month. The results of the sensitivity analysis of the meatball production plant projections are presented in Table 8 and Figure 6.

Table 8. Sensitivity Analysis of Expansion Projections

		0	1	2	3	4	5
Aldep Cost (Rp)	5%	797.040	836.892	878.736	922.673	968.807	1.017.247
	10%	797.040	876.744	964.418	1.060.860	1.166.946	1.283.641
	15%	797.040	916.596	1.054.085	1.212.198	1.394.028	1.603.132
Blocplan Cost (Rp)	5%	1.366.761	1.435.099	1.506.854	1.582.197	1.661.307	1.744.372
	10%	1.366.761	1.503.437	1.653.781	1.819.159	2.001.075	2.201.183
	15%	1.366.761	1.571.775	1.807.542	2.078.673	2.390.474	2.749.045

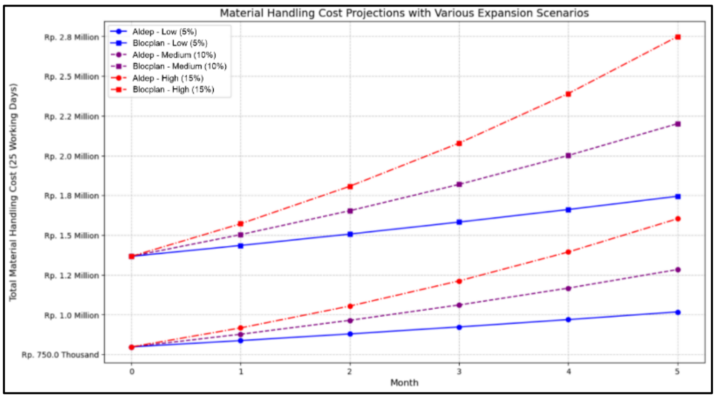

Figure 6. Cost Sensitivity Analysis with Several Scenarios

Sensitivity analysis is also conducted through a Monte Carlo simulation to determine cost savings in various random scenarios by considering uncertain variables such as changes in demand, changes in material handling costs, and changes in distance between departments. Monte Carlo sensitivity analysis is conducted with 1,000 iterations and will compare Aldep as the most efficient method compared to Blocplan. The results of the sensitivity analysis through the Monte Carlo simulation show that the positive probability value generated is 98.3% and the negative probability value generated is 1.7%. The results of the probability analysis show that Aldep has a very consistent cost advantage in providing positive savings on material handling costs compared to Blocplan. Kim also stated that a negative probability value of <5% indicates that there is high confidence. [39].

Sensitivity analysis of the Monte Car. The simulation, considering the uncertainty variables of demand change, material handling cost change, and inter-department distance change, obtained positive results. Monte Carlo randomizes these variables in a predetermined range. The results of the Monte Carlo simulation on changes in demand, changes in material handling costs, and changes in distance between departments are presented in Tables 9-11.

Table 9. Monte Carlo Simulation of Demand Change

Demand Scenarios	Saving Averages	Positive Savings Probability
<0%	Rp. 388.070	96.2%
>0%	Rp. 1.252.819	99.7%
-100% until -50%	Rp. 201.346	93.1%
-50% until 0%	Rp. 574.795	97.8%
0% until 50%	Rp. 984.621	99.5%

50% until 100%	Rp. 1.521.018	99.9%
>100%	Rp. 1.873.492	100%

Table 10. Monte Carlo Simulation of Material Handling Cost Changes

Cost Scenarios	Saving Averages	Positive Savings Probability
<0%	Rp. 691.327	97.4%
>0%	Rp. 921.584	98.9%
-50% until -25%	Rp. 571.462	96.3%
-25% until 0%	Rp. 811.192	98.1%
0% until 25%	Rp. 887.436	98.7%
25% to 50%	Rp. 942.357	99.0%
>50%	Rp. 968.750	99.2%

Table 11. Monte Carlo Simulation of Distance Change

Distance Scenarios	Saving Averages	Positive Savings Probability
<0%	Rp. 924.732	99.1%
0% until 50%	Rp. 782.416	98.0%
50% until 100%	Rp. 643.255	96.4%
>100%	Rp. 511.873	94.2%

The Monte Carlo simulation results show that the resulting savings probability is positive. This shows that Aldep is confidently superior to Blocplan. In addition, the positive savings probability results also show a consistent positive value close to 100%. A probability value close to 100% indicates that the potential uncertainty is smaller than what will occur in the future. [40]. To validate the results that Aldep.It is better than Blocplan, partial rank correlation coefficient, and elasticity analysis were conducted.

The partial rank correlation coefficient analysis found that the uncertainty variables are changes in demand, changes in material handling costs, and changes in distance between departments. The partial rank correlation coefficient analysis results show that demand changes have a value of 0.81 with a p-value of <0.0001, changes in material handling costs have a value of 0.24 with a p-value of <0.0001, and changes in distance have a value of -0.42 with a p-value of <0.0001. Based on the results obtained above, all variables have a significant correlation to cost savings. In more detail, it is known that changes in demand have the strongest influence and control over other parameters. In contrast, changes in distance have a negative value because they act as a controlled variable. This is in line with the statement of Camaj et al., which states that changes in demand in a system will have a major impact in the form of increased material handling costs and distance. [41].

Sensitivity analysis was also conducted using the uncertain variables of demand change, material handling cost change, and distance change between departments. The results show that changes in demand have an elasticity value of 0.65, changes in material handling costs of 0.14, and changes in distance of -0.31. Based on the elasticity values obtained, it is known that every 1% increase in the three variables above corresponds to the resulting elasticity value. In demand, every 1% increase will contribute 0.65% to cost savings in material handling costs, and every 1% increase will contribute 0.14% to cost savings. In comparison, in distance elasticity, every 1% increase in distance will contribute to a decrease in cost savings by 0.31%. This is in line with the statement of Aslan et al. that the higher the distance traveled, the higher the costs generated, thus reducing the resulting cost savings. [42].

Conclusion

The implementation of the Blocplan and Aldep algorithms effectively reduced the moment of movement, thereby minimizing material handling costs associated with the meatball factory. The layout proposed by the Blocplan algorithm resulted in a cost of Rp1,366,761.6, representing a 13.6% reduction in the initial layout cost. Conversely, the layout proposed by the Aldep algorithm yielded a cost of Rp797,040, representing a 49.6% reduction from the initial layout. It is noteworthy that the building structure underwent substantial modifications, necessitating a considerable initial investment but resulting in a favorable long-term outcome. Sensitivity analysis indicates that the layout evaluation utilizing Aldep exhibits a higher projected expansion potential compared to Blocplan, as it results in enhanced cost savings. In the Monte Carlo analysis, a positive probability value of 98.3% and a negative probability of 1.7% were obtained, indicating that Aldep has a very consistent cost-saving advantage over Blocplan. However, this study has several limitations. Specifically, Blocplan and Aldep operate under certain deterministic assumptions regarding material flow patterns and input parameters. However, it is important to note that the findings are specific to this particular meatball factory case study. Consequently, the generalizability of these results to other industries or scenarios necessitates further validation. Further studies are recommended to consider variations in production capacity, demand dynamics, and the application of other algorithms that are more adaptive to changes in the factory environment in real time.

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