ISSN : 1978-774X

GROUP TECHNOLOGY AND DYNAMIC MODIFIED SPANNING TREE (DMoST) IMPLEMENTATION FOR DYNAMIC CELLULAR LAYOUT PROBLEM

Yogi Yogaswara[1] , Sri Wahyuni[2].

[1] Industrial Engineering, Faculty of Engineering, Pasundan University
[2] Student of Industrial Engineering, Faculty of Engineering, Pasundan University
yogiyoga@unpas.ac.id

ABSTRACT

In a manufacturing firm with job order system, the layout of the production facility at the company requires many improvements because there is a change in the quantity and variety of products frequently. To overcome this, a firm must be able to plan the design of facilities for orders already received or to order which will come good for the short term or the long term in accordance with the consumer orders. Plans were made for the company to maximize performance while keeping minimum costs.

The ways to overcome the above problems, this research proposes how to the improvement of production facility layout which machine layout using the concept of Group technology (GT). With the GT will be formed a manufacturing cells, where each cell consists of machines that will process the creation of a component that has a resemblance in the process. For the application of the Group's technology, the method used is the method of clustering i.e. Production Flow Analysis (PFA), Rank order clustering (ROC) and Direct clustering algorithm (DCA).

For planning in the future after being creation of a manufacturing cell with ROC method, then occurs to the addition of 6 new types of products then calculation by Dynamic modified spanning tree (DMoST) and obtained suggestions for rearrangement machine cost 11000 occurs rearrangement machine 2 times that in the period of 1-5 with a sequence of machine are 2-1-3-4-9-7-5-6-8 and in the period 6 with a sequence of machine are 2-1-3-4-8-7-5-6-9 that produce a total cost about Rp 18,627,509.79. Meanwhile, for the 3600 arrangement cost occurs rearrangement machine 3 times that in the period 1-3 with a sequence of machine 2-3-4-9-7-6-5-8 in the period 4-5 with the sequence machines are 2-1-3-4-9-7-5-6-8 and in the period 6 are 2-1-3-4-8-7-5-6-9 that produce a total cost about Rp 7,073,114.04.

Key words: Group technology, Clustering, Dynamic modified spanning tree (DmoST, Silver-Meal Algorithm

1. INTRODUCTION

1.1. Background

The rapid development of industry in Indonesia have an impact on global competition between the companies. Improving the competitiveness of the industry from other countries is an indispensable readiness by the local industry in the face of the current application of the free market.

For companies job order, the timeliness of order completion is one of the important aspects of winning the competition in addition to the factors of quality and price. Diverse array of manufactured products and to anticipate changes in demand then the company should be able to choose the type of production facility layout representative. Remote engine placement will increase the time and cost of material handling. Type appropriate layout to overcome that group technology layout. Type this layout can increase the flexibility in the layout process and productivity in product layout for group technology is the composition of the second layout.

Cellular Manufacturing (CM) is a direct application philosophy Group technology in the manufacturing process. Group technology (GT) of the proposed by Mitrofanov and Burbidge is the philosophy that exploits the similarity of attributes between a set of objects. CM represents the parts as objects produced. While the definition of a similarity of attributes can be any semblance of geometric shapes the parts, similarity of production processes, and others. A set parts that are similar (part family) is formed and then processed in groups of machines (machine cell).

ISSN : 1978-774X

Through the implementation of the CM can be obtained advantages such as a reduction in cycle time, reducing in-process inventory, improving product quality, lead time is shorter, reducing the need of tools, increased productivity, controlling the overall operation better and others (Singh, N and Rajamani, D, 1996).

Additionally, companies that use the job order system should also have a layout plan for the long term. This is because the product has the characteristics of the material flow fluctuations from time to time due to business dynamics, this condition is a condition of dynamic layout. This dynamic layout problems was introduced by Rosenblatt (1986), is a wider problem of static layout with the assumption that it may be desirable to make changes in the layout of the time.

Therefore, the layout of the dynamic is the right choice to accommodate the changes that happen in which the changes that may occur include: changes in product volume, changes in the number of production and changes in the characteristics of the products in the production line, all of the above changes can be dealt with to rebalance among the changes the layout of the facility with the cost of moving goods, because the layout of the facility is the primary support component production process as a whole, it is an impact on production costs.

1.2. Formulation of Problem

From the background of problem, can be formulated that the problems faced in this research are:

1. How to classify machinery and parts in manufacturing cells using a heuristic method?
2. How to design the machines layout in a dynamic layout issues / dynamic layout problem (DLP) at the present time and the layout in the future?

1.3. Restrictions of Problems

In order for the problems discussed in this research is not very extends (more directional) and without reducing the objectives are achieved, then there should be restrictions on the scope of the problem, which the limitations as follows:

1. The layout of the existing facility is currently used as a reference for grouping machines into cells.
2. The order of the process is the order of the processes used by the company today.
3. The changes are considered in this method is associated with changes in the types of new products.
4. Orientation machine known.
5. Building per department cuboid.

1.4. Research purposes

The purpose of this research is:

1. Obtain appropriate method to classify the machines and parts in manufacturing cells using a heuristic method.
2. Obtain the machines layout design in a dynamic layout issues / dynamic layout problem (DLP) at the present time and the layout in the future.

1.5. Benefits of research

The benefits of research in this thesis are:

1. Provide knowledge about aid contributions to the terms of suggestions layout of the facility with the application of group technology uses heuristic methods.
2. Provide knowledge about assistance contribute ideas to the company in terms of suggestions dynamic facility layout.

2. THEORETICAL BACKGROUND

2.1. Definition Facility Layout

The layout of the facility can be defined as a procedure for setting the buildings where people, materials, and machines work together for a particular purpose. (Heragu, 2008). One classification of the layout is based on the characteristics of the data flow.

2.2. Classification Problems Layout

One classification of the layout is based on the characteristics of the data flow. Data flow is relatively constant over the planning period are grouped into static layout issues, while the data stream is changed during the term of the planning period will be grouped in a dynamic layout problems.

There is 2 type of the dynamic layout, namely:

1. Dynamic Deterministic

In a deterministic environment, the type of product and the volume fluctuates from time to time, but can be estimated with reasonable accuracy. The production process is relatively constant between the facilities and material flow for each period (in units of time, eg, month, quarter, or year) can be known

2. Dynamic Stochastic

If the environmental conditions are stochastic, then modeling the quadratic assignment will not be applicable. Because the issue of the layout will also involve elements of uncertainty that is not handled by a quadratic assignment models

2.3. Single-row and Multi-row Layout

Single-row layout is usually called as problem of allocating one-dimensional space. According to its name, the problem of facility layout arranged linearly one line and one line, to detail can be seen in the Figure below.

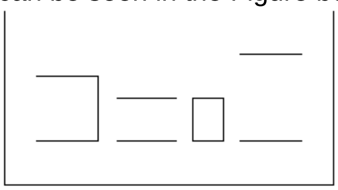


Figure 1 Single-row layout

This model can be used to formulate a layout problem for facility issues with length equal or unequal. Purpose function of the model of single-row layout is meminimasikan cost of transfer of materials between facilities.

Whereas multi-row layout often called the problem of allocating two-dimensional space. The assumption of this model is the size and shape of the facility (department) and spacious all the same, and the material flow is constant over the planning period.

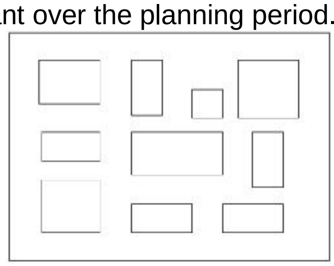


Figure 2 Multi-row layout

2.4. Types of Layout in Manufacturing System

There are five types of layout type used in manufacturing systems (Sunderesh S. Heragu: 2008, p 39), as follows:

1. Product Layout

The layout is based on the product, commonly known as product layouts or production line layout, is a method of setting and placement of work stations based on the sequence of operations of a product. The system is designed to produce products with a variety were low and high volume (mass production). The main objective of this layout is to reduce the material displacement process and also ease control in its production activities.

2. Process Layout

Layout settings by placing all machinery / equipment has a type / kind same into the one department, for example: the manufacturing industry. The layout of this type conform to those used in industry that are receiving job orders with varying kinds of products made in the amount that is not too large. This layout is a method of setting and placement of all machinery and production equipment have the same type or types into a single department.

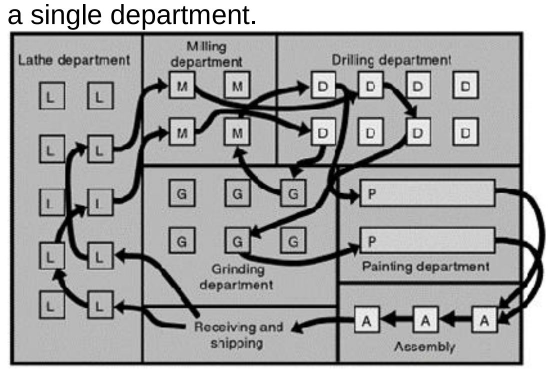


Figure 3 The Layout Process

Source: Heragu, S, 2008. Facilities Design, Third Edition.Taylor & Francis Group, LLC.

3. Fixed position Layout

The layout fixed position, commonly known as fixed material location or fixed position layout, is a method of setting and placement work station in which the materials or the main components will remain in the position / location is, whereas production facilities such as tools, machines, humans, and other components is moving towards the location of the main components.

4. Group technology (GT)-based layout

This layout is based on the grouping products or components to be created. The products are not identical grouped based on

ISSN : 1978-774X

the processing steps, shape, machine or equipment used, and so on.

5. Hybrid layout

Not all companies able to apply one type of layout. As a growing company with increasing trajectory track and volume production, will probably find that some of the production requires a product layout, some other layout fixed position. So some companies use hybrid layout were has characteristics such as GT.

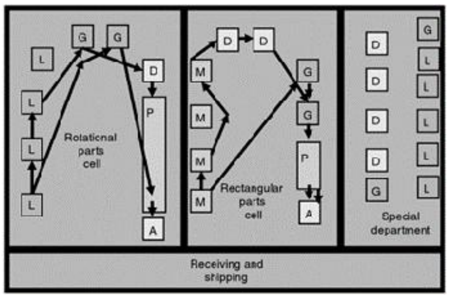


Figure 4 A GT-Base Of Cellular Manufacturing Layout
Source : Heragu, S, 2008. Facilities Design, Third Edition.Taylor & Francis Group, LLC.

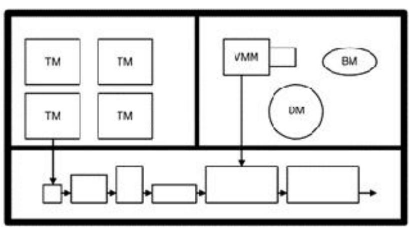


Figure 5 Hybrid Layout
Source : Heragu, S, 2008. Facilities Design, Third Edition.Taylor & Francis Group, LLC.

2.5. Group technology

Group technology is a production method that is relatively new short-often used in situations of job-shop. Usually the groups are not equal grouped into one group based on common component form, not the similarities end use. In production systems, group technology can be applied to different problem areas. For the design of components, many components have similar shapes. These components can be grouped into the families draft. One new design can be created by modifying an existing design components within the same family. By using this concept, the components can be identified from the characteristics of the components.

Cellular Manufacturing (CM) / Cellular Manufacturing System (CMS) is a direct application of the philosophy of Group Technology in the manufacturing process. Cellular manufacturing system is a link between conventional systems toward a more modern system. Cellular manufacturing system is the decomposition of the system into groups of machines and / or components.

Group technology is a philosophy that can help increase efficiency by classifying a product similar to the family. Group technology lay-out are divided into three categories (Singh, 1996):

1. GT flow line layout

This layout mode is used when all components of the group following the rules of the same machine. GT flow line operates as a mixed-product assembly line system. Transfer mechanism assembly is sometimes used for the handling of components in the group.

2. GT cell layout

In GT Cell Layout allows moving parts / moved from one machine to another machine. This is very different from the GT Flow Line where the components within the group following the order of the same machine. The machines in the GT Cell Layout placed close together to reduce movement of material handling.

3. GT center layout

Layout mode is based on the preparation of the machine. This arrangement can improve material handling and appropriate changes during the product-mix change frequently.

2.5.1. Cluster Analysis

Cluster analysis is intended to group objects into a homogenous cluster based on the nature or characteristics of the object. Application of cluster analysis on the technology group is a grouping of parts into a family parts and cells machines. This grouping produces two different layouts (Kusiak, 1990), namely:

1. Physical Layout The machine (physical machine layout) In this layout is done arranging and editing layout machinery parts on the basis of family and the cell machinery.

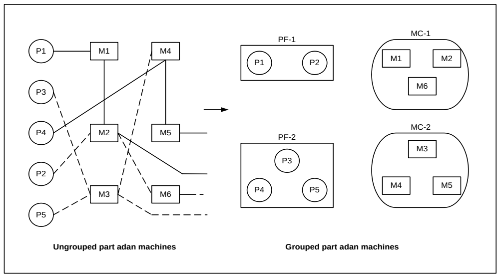


Figure 6 The Physical Machine Layout
Source: Kusiak, A., 1990. Intelligent Manufacturing System, Prentice Hall, New Jersey

2. The layout engine logically (logical machine layout) On a logical layout, machines are grouped into logical cell engines and engine position is not changed change. Logical grouping can be applied in some cases the production system where the change machine is physically impossible.

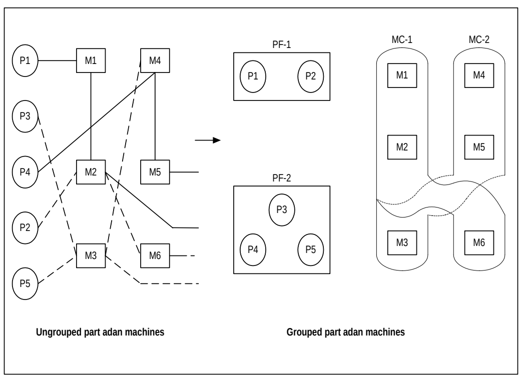


Figure 7 The Logical Machine Layout
Source: Kusiak, A., 1990 Intelligent Manufacturing System, Prentice Hall, New Jersey

2.6. Establishment of Manufacturing Cells

2.6.1. Establishment of Production Flow Analysis (PFA) / Incident Matrix

PFA or commonly called the incident matrix is a systematic procedure which analyzes information from the manufacturing process of a part (Singh and Rajamani: 1996, p 34). PFA consists of inputs 0 and 1, in which a first input indicating that the machine is used while the input of 0 indicates that the machine is not used for processing the part in question.

2.6.2. Method of Manufacturing Cell Formation

1. Rank order clustering (ROC)

Cluster method based on sorting the rows and columns of a matrix of machine-part linkages have been studied a lot of people, including rank order clustering algorithm (ROC) is a matrix in which the cluster can be identified visually.

ROC algorithm describes the binary value for each row and column, row and column rearrangement in decreasing order of their binary value then identification of the [King, 1980].

This algorithm was introduced by King (1980) for grouping machine parts. This method provides a mathematical calculation technique is simple, effective and efficient (Singh and Rajamani: 1996, p 42). The algorithm is as follows:

- Rows formula

$$C_m = \sum_{p=1}^{P} 2^{P-p} . a_{pm}$$

- Columns formula

$$r_p = \sum_{m=1}^{M} 2^{M-m} . a_{pm}$$

2. Direct clustering algorithm (DCA)

This algorithm first developed by Chan and Milner (1982), later amended by Wemmerlov (1984) provides a correction to the original algorithm to obtain the desired revision algorithm. DCA is a clustering algorithm where the conditions at the initial matrix is still partially in the form of a matrix.

2.7. Performance Measure

To perform alternative selection of the best manufacturing cell formation required a comparison of the quality of the solution. Therefore we need a measurement called a performance measure.

a. Grouping efficiency (η)

Introduced by Chandrasekaran and Rajagopalan (1986) (Singh, 1996). The kindness of a solution depends on the level of utilization (utilization) of machinery in the cell and inter-cell movement (inter-cell movement). Therefore, the grouping efficiency is proposed as a weighted average of the two efficiency $\eta 1$ and $\eta 2$.

$\eta = w\,\eta 1 + (1- w)\,\eta 2$ …...........................(2.1)

$\eta_1 = \frac{o-e}{0-e+v}$

$\eta_2 = \frac{MP-o-v}{MP-o-v+e}$

b. Grouping efficacy (τ)

$\tau = \frac{o-e}{o+v}$

Information:

η1 = ratio of the number of input value of 1 in block diagonal to the total number of elements in a block (either 0 or 1)

η2 = ratio of the number of input values of 0 outside the block diagonal to the total number of elements outside the block (either 0 or 1).

M = the number of machines

P = number of part

W =weighting factor (number 0.5 recommended)

o = whole number 1 which is on matrix

e = the number 1 in the outer cell

v = number number 0 in the cell

2.8. Dynamic Modified Spanning Tree (DMoST)

The algorithm is a combination algorithm Modified Spanning Tree for sorting machine into the layout with single-row structure with Silver-Meal algorithm for determining the length of the planning time window including the determination of the total costs for the resulting layout.

In DMoST algorithm, the layout of the single-row structure resulting consider the changes to routing products in the coming period.

These changes will be implemented into a planned event or hypothetical scenarios to determine the performance DMoST algorithms to be designed. This algorithm was developed by Yogaswara, 2014.

2.8.1. Modified Spanning Tree (Most)

Algorithm Modified Spanning Tree is used in the design of the layout of the manufacturing cell with the structure of single-row to generate a sequence of departments or machines in the layout, do not notice any change in routing, so that the layout of the Modified Spanning Tree Static inefficient if they are used in future periods , Modified Spanning Tree algorithm tries to find the order of the department or machine with a sum of weights of the edges associated with the proximity of the engine department or maximum.

2.8.2. Silver-Meal Lot Sizing Planning To Determine Length of Time Window

In determining the length of planning time window algorithm Silver-Meal is an important process in which a material requirements planning lotting process. Lotting process is a process for determining the amount of the component items that should be provided for the needs of the production process.

In determining the length of the planning time window for dynamic facility layout planning, length of the planning time window will be related to the cost of rearranging the layout and the cost of removal of material.

The smaller length of the planning time window, means that the more often reset the layout, otherwise the greater the length of the planning time window will reduce the long frequency

2.8.3. Terminology Notation and Formulations

Here are the terminology and the formulation used in the Modified Dynamic Spanning Tree algorithm (Yogaswara, 2000) for dynamic facility layout single-row.

$$f'_{ijk} = (f_{ijk})\left[d_{ijk} + \frac{1}{2}\,(l_{ik} + l_{jk})\right] \text{..(3.15)}$$

Where :

f_{ijk}' = The weight of the machine closeness I to j in period k

(F_{ijk})= matrix material flows in the period k

$[d_{ijk}]$ = matrix within the period k

l_{ik} = length of period k to i engine

l_{jk} = Long periods of machine j to k

k = k Period

$$\frac{TRC_T}{T} = \frac{R+M\left[\sum_{k=1}^{T}(k-1)W_k\right]}{T} \text{...... (3.16)}$$

Where :

TRC_T= Total cost of the relevant during period T

R = cost of rearranging the layout

W_k = Total OMH layout configuration the period to k

(K-1) = The initial period where the length planning time window tentative starts counting

T = period last requirement was included in the long planning time window tentative.

$\sum_{k=1}^{T} W_k$ = Number of total OMH for each layout configuration for the entire period k

$[f'_{ijk}]$ = weighting matrix proximity

L_k = Length of planning time window with a period k

2.9. Material handling

Material handling can be defined as the movement, storage, protection, material control throughout the manufacturing and distribution process including the use and disposal. Or it could be defined as the provision of material quantities, condition, position, time and the right place to get the cost efficient.

Planning material handling in companies or factories must adjust the layout or the layout of the company as a good layout can handle the material handling system as a whole. If the material handling systems that are less systematic become a pretty big problem and disrupt the production process constrains experienced by the company in the process and production facilities are in terms of the transfer of raw materials that are less efficient. As in the production process there is a flow of material removal that intersect (cross movement) due to the layout of the engine a less regulated so as to result in the production process is interrupted, the distances between the production department far enough so that it can lead to material handling costs are sizeable.

3. RESEARCH METHOD

Flowchart of solving the problem is shown in Figure 3.1.

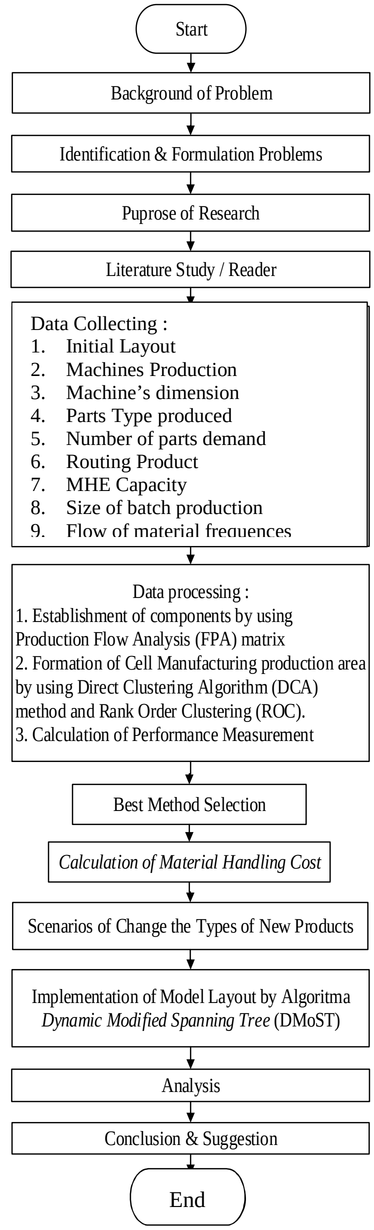


Figure 8 Framework of Research

4. RESULT AND DISCUSSION

4.1. Production Flow Analysis (PFA)

The Preliminary Matrix Shown in Table 1.

Table 1 Preliminary Matrix

		COMPONENT								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
MACHINE	**1**	1	1	1	1	1	1	1	1	1
	2	0	0	0	0	0	0	0	0	1
	3	1	1	1	1	1	1	1	1	0
	4	1	1	1	1	1	1	1	1	1
	5	1	1	1	1	1	1	0	0	0
	6	0	0	0	0	1	1	0	1	0
	7	1	1	1	1	0	0	1	1	1
	8	0	0	0	0	0	0	1	0	0
	9	1	1	1	1	0	0	0	0	0

4.2. Rank order clustering (ROC)

Table 2 Matrix End-Machine Component grouping By ROC

Machine	Part								
	1	2	3	4	5	6	8	7	9
1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	0
5	1	1	1	1	1	1	0	0	0
7	1	1	1	1	0	0	1	1	1
9	1	1	1	1	0	0	0	0	0
6	0	0	0	0	1	1	1	0	0
8	0	0	0	0	0	0	0	1	0
2	0	0	0	0	0	0	0	0	1

Table 3 Cell Formation Method with ROC

Machine	Part								
	1	2	3	4	5	6	8	7	9
1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	0
5	1	1	1	1	1	1	0	0	0
7	1	1	1	1	0	0	1	1	1
9	1	1	1	1	0	0	0	0	0
6	0	0	0	0	1	1	1	0	0
8	0	0	0	0	0	0	0	1	0
2	0	0	0	0	0	0	0	0	1

The results of the cell groupings can be seen in Table 3. Based on the above calculation, the end of the formation is obtained by a decimal value equivalent (DE) are sorted by ranking the largest to smallest so that such formations are the result of the grouping. Machine cell group 1 consists of the machine (M1, M4, M3, M5, M7, M9); part / component (P1, P2, P3, P4), the cell group 2 consists of machine (M6); part / component (P5, P6, P8) and a cell group 3 consists of machine engine (M8, M2); part / component (P7, P9). The results of the cell groupings can be seen in the table below

4.3. Direct clustering algorithm (DCA)

Table 4 Matrix End-Machine Component grouping By DCA

MACHINE	COMPONENT									
	1	2	3	4	5	6	7	8	9	
1	1	1	1	1	1	1	1	1	1	9
4	1	1	1	1	1	1	1	1	1	9
3	1	1	1	1	1	1	1	1	0	8
7	1	1	1	1	0	0	1	1	1	7
5	1	1	1	1	1	1	0	0	0	6
9	1	1	1	1	0	0	0	0	0	4
6	0	0	0	0	1	1	0	1	0	3
2	0	0	0	0	0	0	0	0	1	1
8	0	0	0	0	0	0	1	0	0	1
	6	6	6	6	5	5	5	5	4	

Table 5 Formation Methods Cells with DCA

MACHINE	COMPONENT									
	1	2	3	4	5	6	7	8	9	
1	1	1	1	1	1	1	1	1	1	9
4	1	1	1	1	1	1	1	1	1	9
3	1	1	1	1	1	1	1	1	0	8
7	1	1	1	1	0	0	1	1	1	7
5	1	1	1	1	1	1	0	0	0	6
9	1	1	1	1	0	0	0	0	0	4
6	0	0	0	0	1	1	0	1	0	3
2	0	0	0	0	0	0	0	0	1	1
8	0	0	0	0	0	0	1	0	0	1
	6	6	6	6	5	5	5	5	4	

Based on the results of iteration-1, obtained by the formation of the end base on biggest to the smallest value so that the formation of such a grouping results. Machine cell group 1 consists of the machine (M1, M4, M3, M7, M5, M9); part / component (P1, P2, P3, P4) and group 2 consisted cell engine of the machine (M6, M2, M8); part / component (P5, P6, P7, P8, P9).

4.4. Calculation of Performance Measure

Calculation of performance measure used to select the best alternative manufacturing cell grouping of both methods.

- Rank order clustering (ROC)

Known to :

M = 9, P = 9 w = 0.5, o = 48, e = 19, v = 2

- *Grouping Efficiency* (η)

$$\eta_1 = \frac{o-e}{o-e+v} = \frac{48-19}{48-19+2} = 0{,}94$$

$$\eta_2 = \frac{MP-o-v}{MP-o-v+e} = \frac{9x9-48-2}{9x9-48-2+19}$$
$= 0{,}62$

$\eta = w\,\eta_1 + (1\text{-}w)\,\eta_2$
$= 0{,}5x0{,}94 + (1\text{-}0{,}5)0{,}62$
$= 0{,}78$

- *Grouping Efficacy* (τ)

$$\tau = \frac{o-e}{o+v} = \frac{48-19}{48+2} = 0{,}58$$

- *Direct clustering algorithm (DCA)*

Known to :

M= 9, P = 9,w = 0,5, o = 48, e = 19, v = 10

- *Grouping Efficiency* (η)

$$\eta_1 = \frac{o-e}{o-e+v} = \frac{48-19}{48-19+10} = 0{,}74$$

$$\eta_2 = \frac{MP-o-v}{MP-o-v+e} = \frac{9x9-48-10}{9x9-48-10+19}$$
$= 0{,}55$

$\eta = w\,\eta_1 + (1\text{-}w)\,\eta_2$
$= 0{,}5x0{,}80 + (1\text{-}0{,}5)0{,}59 = 0{,}65$

- *Grouping Efficacy (τ)*

$$\tau = \frac{o-e}{o+v} = \frac{48-19}{48+20} = 0{,}50$$

Table 6 Performance Measure ROC method and DCA

Performance Measure	ROC	DCA
Group Efficiency (ɧ)	0.78	0.65
Group Efficacy (τ)	0.58	0.50

From the calculation method of rank order clustering (ROC) has a value higher performance measure. Therefore, we use the results of such grouping for calculation and subsequent analysis. Where the grouping is divided into three manufacturing cells.

Table 7 Formation of Cell Engineering Methods ROC

	Part Family	Machine Group
Sel 1	1-2-3-4	1-4-3-5-7-9
Sel 2	5-6-8	6
Sel 3	7-9	8-2

The engine of the cell grouping, there are some alternative arrangement of the cell machinery that can be seen in the table below:

Table 8 Distance Total Material handling At Whole Cell Engineering Alternatives

Alternative	Order of the Cell Machinery	Distance of Material Handling	Total Distance of Material Handling (m)
Alternative 1	Sel 1, Sel 2, Sel 3	381,18	1683,45
Alternative 2	Sel 1, Sel 3, Sel 2	373,92	1590,99
Alternative 3	Sel 2, Sel 1, Sel 3	313,67	1197,26
Alternative 4	Sel 2, Sel 3, Sel 1	239,68	950,93
Alternative 5	Sel 3, Sel 1, Sel 2	300,28	1265,96
Alternative 6	Sel 3, Sel 2, Sel 1	262,48	967,28

From Table 8 above, the cell makeup of machine alternate 4 has a range of material handling the fewest of the cell structure and other alternative engine is equal to 239.68 meters with a total distance amounted 950.93 meters, arrangement proposed alternative machine 4, then the cell makeup of the proposed machine is using the cell makeup of machine alternative 4.

4.5. Calculation of cost of Material handling Before Relayout

Based on the distance between the machine and the frequency of material handling, it can be determined the total distance traveled during the activity of the production process. Table of results calculation of total distance is as follows:

Table 9 Distance Total distance and Material handling

No	Name of Component	Frequence	Distance (Meters)	Distance Total (Meters)
1	Manhole type DCP-S Sq	9	40,64	365,76
2	Manhole type DCC-L Sq	4	40,64	162,56
3	Manhole type SCP-Rd	8	40,64	325,12
4	Manhole type SCP-Seal	5	40,64	203,2
5	Bearing Back Cover	1	32,35	32,35
6	Bearing Front Cover	1	32,35	32,35
7	Grill/Sarangan jalan	5	31,51	157,55
8	Insert / Bandul	2	32,85	65,7
9	Roof Drain	1	24,05	24,05
Jumlah			315,67	1368,64

The cost per-part-meter are follows:

1) Determination of the cost of equipment depreciation by using straight line depreciation.
   Depreciation costs per-month:
   $= \frac{2 \times 350.000}{10 \times 12}$ = Rp. 5.833,33/month
2) Operator Cost = 8 x Rp. 17.500
   = Rp. 140.000/day
   = Rp. 2.800.000/month
3) Total operating costs-per-month
   Operating costs = Depreciation + Operator Cost = Rp. 5.833,33 + Rp. 2.800.000 = Rp. 2.805.833,33/month
4) Cost per-meter displacement
   Displacement of material Cost = Total cost/Distance
   = Rp. 2.805.833,33 / 1368,64 meters
   = Rp. 2050,09/meters
5) For the cost of moving parts before re-layout is:
   The cost of moving = Rp. 2.050,09/meters x 1368,64 meters
   = Rp. 2.805.833,33/ month
6) For the cost of moving parts after re-layout is:
   The cost of moving = Rp. 2.050,09 /meters x 950,93 meters
   = Rp.1.949.490,84/month

4.6. Dynamic Modified Spanning Tree (DMoST)

To resolve the problem of dynamic layout, then made the scenario to presence of the addition of new product type. The addition of this type of product was made to anticipate if at any time the company will create new product in accordance with the consumer's order. So the company can fulfill the order by the design of the layout facilities which is planned without worrying about costs that may accrue in the future. To resolve the issue then used the method of Dynamic modified spanning tree (DMoST).

4.6.1. Adjacency Weighting Matrix

Weighting matrix of the proximity is an equality between the flow of materials, distance between the machine and the length of the machine. Weighting matrix of the proximity in this scenario is the basis in determining the moving material cost on the calculation of dynamic machine layout. After calculated, then the weighting matrix of proximity at any period, then generated the arrangement of the machine and total each OMH configuration is as follows:

Table 10 Total Each OMH Configuration

Period	Order of the Machine Single Row Layout	Total each OMH configuration
1	2-1-3-4-9-7-5-6-8	867,43
2	2-1-3-4-9-7-5-6-8	867,43
3	2-1-3-4-9-7-6-5-8	802,51
4	2-1-3-4-9-7-5-6-8	904,43
5	2-1-3-4-9-7-5-6-8	972,43
6	2-1-3-4-8-7-5-6-9	916,74

4.6.2. Determination of the length of the Time window Planning

A long time window planning, is affected by the transfer of the cost of materials and the layout set up cost, where transfer material obtained from the OMH each configuration which has been calculated before, while for the layout set up cost has been set amount of 11000,00 and 3600 for one time reset.

- *For Rearrangement Cost 11000*

Table 11 Determination of the length of the Time window Planning with Silver-meal Algorithms 11000 Rearrangement

Period	T	OMH each Configuration	M(T-1)Wk	M[Σ(T-1)Wk]	TRC (T)	TRC(T)/T
1	1	867,43	0	0	11000	11000
2	2	867,43	867,43	867,43	11867,430	5933,715
3	3	802,51	1605,02	2472,45	13472,450	4490,817
4	4	904,43	2713,29	5185,74	16185,740	4046,435
5	5	972,43	3889,72	9075,46	20075,460	4015,092
6	6	916,74	4583,675	13659,135	24659,135	4109,856
6	1	916,74	-	-	11000	11000

The length of the Time window Planning is done by the planning of the time window for this scenario is in the period 6.

Table 12 Results of Calculation Silver-meal Algorithm with Rearrangement Cost 11000

Periode	1	2	3	4	5	6	Total
Weight Flow	867,43	867,43	802,51	904,43	972,43	916,74	5330,97
Time Window	4414,23					916,74	5330,97
OMH	3546,8	2679,37	1876,86	972,43	0	0	9075,46

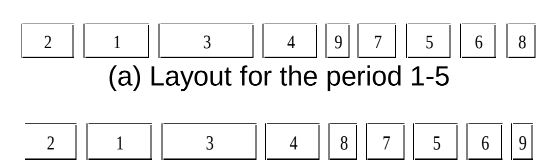
- Transfer material cost:

= (Total OMH) x (Cost per-unit of distance for the unit flow)
= (9075.46) x (2050.09)
= Rp 18,605,509.79

- Total Rearrangement cost:

= (Reset Frequency) x (Rearrangement cost)
= (2) x (11000) = Rp 22,000.00

- Total Cost = (Transfer material cost) + (*Rearrangement cost*)
  = (18,605,509.79) + (22000)
  = Rp 18,627,509.79



(a) Layout for the period 1-5
(b) Layout for the period 6

Figure 9 The Dinamic Single-row Layout

➢ *For Rearrangement Cost 3600*

Table 13 Determination of The length of the Time window Planning with Silver-meal Algorithms with Rearrangement 3600

Period	T	OMH each Confoguration Wk	M(T-1)Wk	M[Σ(T-1)Wk]	TRC (T)	TRC(T)/T
1	1	867,43	0	0	3600	3600
2	2	867,43	867,43	867,43	4467,430	2233,715
3	3	802,51	1605,02	2472,45	6072,450	2024,150
4	4	904,43	2713,29	5185,74	8785,740	2196,435
4	1	904,43	0	0	3600	3600
5	5	972,43	3889,72	3889,72	7489,720	1497,944
6	6	916,74	4583,675	8473,395	12073,395	2012,233
6	1	916,74	0	0	3600	3600

Total cost per-period consistently decreased in three of the first planning period, that is from 1 up to 3 periods and increased in the period 4. In the period 4 the total cost per-period decreases during the next that is period 5 and increased at period 6.

Table 14 Results of Calculation Silver-meal Algorithm with Rearrangement Cost 3600

Periode	1	2	3	4	5	6	Total
Weight Flow	867,43	867,43	802,51	904,43	972,43	916,74	5330,97
Time Window	2537,37			1876,86		916,74	3454,11
OMH	1669,94	802,51	0	972,43	0	0	3444,88

- Transfer material cost:

= (Total OMH) x (Cost per-unit of distance for the unit flow)
= (3444,88) x (2050.09)
= Rp 7,062,314.04

- Total Rearrangement cost:

= (Reset Frequency) x (Rearrangement cost)
= (3) x (3600) = Rp 10,800.00

- Total Cost = (Transfer material cost) + (*Rearrangement cost*)

= (7,062,314.04) + (10,800)
= Rp 7,073,114.04

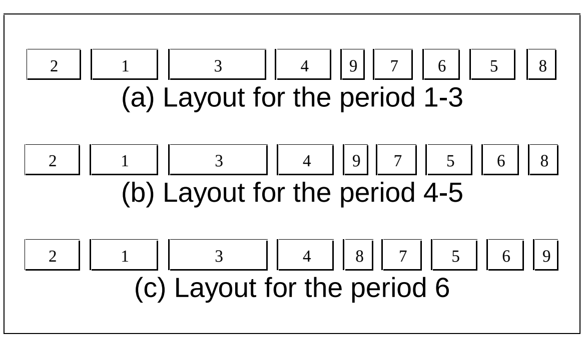


Figure 10 The Dinamic Single-row Layout

5. CONCLUSION AND SUGGESTTION

5.1. Conclusion

The conclusions that can be drawn in a layout redesign (relayout) with the application of Group technology and Dynamic modified spanning tree (DMoST) is as follows:

1. The method cell formation of the machines which is applied in the application of Group technology in the production area is the Rank order clustering (ROC) where these method have the value Group Efficiency and Group Efficacy is greater than the Direct method of clustering algorithm (DCA). On the cell formation of the ROC produces 3 pieces of engine cells i.e. the 1st cells machine consists of machine 1-4-3-5-7-9, the 2nd cells machine consists of machine cells and 6 engines 3 consists of engine 8 and 2. From the cells formation of the cells there are 6 kinds of alternative proposals for the arrangement of the machine where the alternative to cell-4 with all other cells, cell 3 and cell mesin1 engine produces the smallest i.e. material handling distances of 239.68 meters and a total distance of 950.93 meters material handling. Data results layout proposed alternative 4 scenario used for the addition of new types of products. The addition of this new type of products occurred due to the change of order. In this scenario it is assumed there are 6 kinds of new product additions to 6 periods where such changes occur only one product for each period with rearrangement cost of 11000. On the initial conditions of the layout cell manufacturing machine is the path of the multi-row, however, in this scenario the existing layout is assumed as a single-row layout.
2. On the Spanning Tree algorithm is Modified (MoST), the order of the machine which is formed based on the proximity of the weights (weight adjacency) from each machine that has a maximum goal to manage the entire flow times distance or displacement cost of materials. Using this algorithm, then the known total Material Handling Cost each configuration. The algorithm Silver-Meal, the greater the long planning time window will reduce frequencies reset layout which means reducing the cost of setting the layout but

resulted in increased costs of moving materials. And vice versa, the smaller the long planning time window means that the more often done resetting the layout that will lower the cost of moving material, but adds to the cost of resetting the layout. The long planning time window for the first planning period is from 5 by order of the machine 2-1-3-4-9-7-5-6-8. While in the last period of planning, retrieved the layout engine with the sequence of machine 2-1-3-4-8-7-5-6-9 in the period 6. The results of the design of the layout of dynamic manufacturing cells to produce the total fare 11000 rearrangement of Rp 18,627, 509.79 consisting of material transfer fare is Rp 18,605, 509.79 and fare of Rp reset 22, 000.00 for twice reset the layout. In the meantime it's 3600, rearrangement occurs reset the machine as much as 3 times where for a long time planning window for the first planning period is from 1-3 with a sequence of machine 2-1-3-4-9-7-6-5-8 in the period 3. For the planning period i.e. 4-5 machine layout, obtained with the sequence of machine 2-1-3-4-9-7-5-6-8 period 5 and for planning to order the 3 powerplant 2-1-3-4-8-7-5-6-9 in the period to 6. The results of the design of the layout of dynamic manufacturing cells to produce 3600 rearrangement cost a total of Rp 7,073,114.04 consisting of material handling cost is Rp 7,062, 314.04 and Rp resetting fare 10, 800.00 for two times layout reset/rearrangement.

5.2. Suggestion

1. To improve the solution from the results of cell formation can be used clustering methods such as Modified Rank order clustering (MODROC), Rank order clustering 2 (ROC2), Bound Energy Algorithm (BEA) and other clustering methods, but even so still had to do the calculations Performance measurement in order to determine which method has the capability to build a better cell.
2. In the research of dynamic problem, for the preparation and planning of the machine sequence time window is not used as a comparison algorithm, then for future research should use other algorithms, to be seen whether DMoST algorithms that have been used have produced a minimum costs of algorithms that serve as the the comparator.

6. REFERENCES

(a) Apple, J. M., 1990, Plant Layout and Material handling, Translater: Nurhayati., Mardiono, ITB, Bandung.
(b) Heragu, S., 1997, Facilities Design, PWS Publishing Company, Boston.
(c) Heragu, S, 2008. Facilities Design, Taylor & Francis Group, LLC..
(d) Kusiak, A., 1990, Intelligent Manufacturing Systems, Prentice Hall, New Jersey.
(e) Singh, N., dan Rajamani, D., 1996, Cellular Manufacturing Systems: Design, Planning, and Control, Chapman & Hill, London
(f) Yogaswara, Y., 2014. Dynamic Modified Spanning Tree Algorithm For Single-Row Dynamic Facility Layout Problem, Proceeding 7th International Seminar on Industrial Engineering and Management, ISSN : 1978-774X.