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MACHINE LAYOUT DESIGN: A SURVEY

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ABSTRACT

The purpose of this paper is to analyze the use of a product-oriented layout and a work-cell strategy in order to maximize efficiency. These two categories of layout strategies are discussed separately, and are then used collectively in an analysis of the company. The aim is to understand how improvements in layout design could positively impact the future efficiency of the case study. A model was developed and measured using 12 weeks of data in the case study company in South Sulawesi, Indonesia. The findings showed that there is a strong correlation between the cell structure and the product structure of the facility and the overall efficiency of the manufacturing facility itself. The results also show that higher overall efficiency allows facilities to handle much larger workloads and also reduces time in the production process, and the use of machine facilities is also more efficient

Keywords: *Manufacturing industries, Facility layout, Work-cell planning, Efficiency.*

I. INTRODUCTION

Efficient arrangement of layout facilities in a manufacturing company is very important to support the smooth production process. thus developing machine layout is an important step in designing manufacturing facilities because the impact of an efficient layout affects the cost and time of material handling, and productivity. According to Drira et al., (2007) said that good facility placement generally contributes to overall operating efficiency and has been proven to be able to reduce up to 50 percent of total facility operating costs. This is also supported by Urban, (1993) and Tompkins et al., (2003) who say that the layout of a facility has always affected the efficiency and profits of a company.

Several studies have been carried out regarding facility layout issues in the manufacturing industry (Balakrishnan and Cheng, 1998; Kusiak and Heragu, 1987; Meller and Gau, 1996). Planning the layout of the machine in the manufacturing industry depends on several factors including the proximity of the facility, facility resources, the distance between machines, and the location of the machine. Problems in the design of the engine layout can cause large costs and excess time. (Liang and Chao, 2008). According to Apple (1990). Poor layout of production facilities will cause major problems and tend to be difficult to overcome because they are permanent. According to Tomkins (1996), it is estimated that 20% to 50% of operating costs are material handling costs, so an effective layout can reduce these costs by around 10% to 30%.

In addition, the issue regarding the machine layout that developers have been concerned with for some time. Therefore, the company can design the machine layout at the manufacturing facility with the FMS system. Flexible Manufacturing Systems (FMS) can provide a combination of flexibility and economical production. Black, (1993), Browne et al. (1984), Buzacott and Shanthikumar (1980), Groover (1980), and Stecke (1986). Furthermore, FMS focuses on the objectives of maximizing the level of production and minimizing waiting time. According to Heragu and Kusiak (1988) argues that the layout problem for flexible manufacturing systems can be different from the traditional facility layout problem in one important respect. Some examples of work related to other problems in layout design for FMS can be found in Afentakis, Millen, and Solomon (1986), Kouvelis and Kiran (1990), and Leung (1990).

In this article, we study two configurations commonly used for FMS layouts. The first uses a loop conveyor, with machines located around this loop, while the second uses a linear-line material handling system with machines located on one side or both sides. For this research, a case study organization is used; a manufacturing facility for engines, located in South Sulawesi, Indonesia. This paper examines machine redesign for manufacturing facilities and will see how to maximize efficiency in the production process.

II. MATERIALS AND METHODS

A facility layout is an arrangement of everything needed for the production of goods or delivery of services. According to Heragu (1997) a facility is an entity that facilitates the performance of any job. It may be a machine tool, a work center, a manufacturing cell, a machine shop, a department, a warehouse, etc. Additionally, Meyers, (1993) states that engine layout is one of the largest parts of a facility design study. Facility design consists of plant location and building design, as it is known that plant layout and material handling are closely interrelated.

a. Work-cell planning

In cellular layout, machines or production equipment needed to work on a product are grouped in a machine cell. The work-cell layout is one of the most important factors for businesses when trying to maximize efficiency. A work-cell is an arrangement of machines and personnel that focus on making a single product or family of products. In order to increase efficiency in the production process through this layout, an optimal setup of machines and personnel must be chosen. Group technology is used in the manufacturing environment by linking products with similar tasks together in a work-cell. These work-cells are then arranged in order so the finished product will be completed most effectively. Work-cells came about as a result of the modification of the assembly line. The assembly line became very popular around the time that Henry Ford mass-produced the Ford T-Model in 1908. It was the first effective method for mass production (Heizer and Render, 2008). The idea of work-cells was first presented by R.E. Flanders in 1925 and has continually evolved since then (Heizer and Render, 2008).

The work cell layout has many advantages over other forms of layout which are therefore very attractive to certain businesses. This is widely used in factories because of the low variety and high product volume, as discussed in this paper. Only about half of US plants use the work cell method, while 75 percent of large plants use work cell planning to increase efficiency (Heizer and Render, 2008). The strategy used to achieve this is known as the problem of grouping machine parts (MPGP), which focuses on differentiating the family of parts and machine cells (Chan et al., 2006).

According to Kazerooni et al. (1997) and Taboun et al. (1998), by implementing a CMS, one can achieve the benefits of minimizing components of total production costs, namely material handling costs, processing costs, machine duplication costs, the cost of multiple requirements, and the cost of managing some families. The total cost depends very much on the cell configuration.

b. Material handling system

According to El-Baz (2004) Material handling systems ensure delivery of materials to suitable locations. Material handling equipment can be in the form of conveyors (belts, rollers, wheels), automatic guided vehicles (AGV), robots, etc. Material handling systems ensure delivery of material to suitable locations. Material handling equipment can be in the form of conveyors (belts, rollers, wheels), automatic guided vehicles (AGV), robots, etc. (El-Baz, 2004). The type of material handling tool determines the pattern that will be used for machine layout (Devise and Pierreval, 2000; Heragu and Kusiak, 1988). The material handling system together with the layout determines the travel time between engine layout problems. engine and impact throughput (Stecke 1985).

c. Layout flexibility

Developing a flexible machine layout is important because rearranging the layout in response to changes causes production disruptions and machine neglect, and incurs costs for changing handling equipment and replacing machinery Afentakis et al. (1990) show that material handling costs, in-process inventory, and throughput are adversely affected when the FMS loop layout remains static while the product mix changes. FMS differs from classical machining systems because of a higher degree of automation, fewer number of machines, frequent settings, higher volume and flow of information, etc. Hiragu and Kusiak (1988) showed that the type of material handling device (MHD) in FMSs determines the pattern that will be used for the layout of the engine. Stecke and Browne (1985) observed that material handling systems suitable for FMS can be determined based on whether a prismatic or rotational component is employed.

d. A hypothetical case

To illustrate the problem above, hypothetical octas are considered. Company X is involved in wood processing production and acts as an exporter to European and Asian countries. For wood originating from plantations tends to have defective inferiority. This results in reduced yield and quality of sawn wood. Not to mention the presence of extractive materials that often hamper the course of the rotation of woodworking machinery. This can cause problems during the process. One solution to this is to set the machine as needed at the beginning of the production process. The main problem is whether the arrangement of all production facilities has been made as well as possible so that it can achieve a production process that is most efficient and can support the continuity and smoothness of the production process optimally.

e. Research Methodology

This research was conducted from January-April 2019. Data were analyzed by quantitative methods using a process analysis of the machine layout to arrange departments or work stations by minimizing material handling costs. Costs are assumed to be a function of the distance between departments. And this function can be started by:

The Model

Cyrcle time:

$$c = \frac{prduction\ time\ per\ day}{unit\ produced\ per\ day}$$

Efficiency :

$$c = \frac{\sum ti}{NC}$$

ti = the time needed for production (duty time)
N = number of work centers or work stations
C = Cycle time

Minimum Time :

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

Where :
C = total time
n = number of work stations and departments
i, j = Every department,
X*ij* = the amount of burden transferred from the department *I* to department *j*,
C*ij* = time to move expenses between departments *i* and *j*

III. RESULT AND DISCUSSION

a. Layout Analysis to balance assembly lines and determine line efficiency

Balancing lines are usually implemented to minimize imbalances between machines or workers to meet the output potential of the assembly line to be able to produce at a certain level, management must know the equipment, equipment, and work methods used then the time requirements for each assembly. Furthermore, PT. Sekishin Farina Wood Indonesia produced various products such as ABC / Raamhout Profile. ABC Finger Joint, ABC, Skeleton W. Primed, Laminating Board, Door Stick / 5 layer. According to customer requirements. In this study, we only took one sample, the FJLB (finger joint Laminating Board) product through several processes:

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Table (1) FLJB process (finger joint laminating Board)

No	Proses	symbol
1.	Raw Material	RM
	a. Wet raw materials	WRM
	b. Kiln Dry	KD
	c. Dry raw materials	DRM
2.	Planner	PR
3.	CrossCut	CC
4.	Multi Rip	MR
5.	Press Finger Joint	PFJ
6.	Multi Rip	MR
7.	Mouldier	MO
8.	Press Laminating	PL
9.	Planner	PR
10.	Cross Cut	CC
11.	Repair	R
12.	Sander	S
13.	Finish Packing and Lebeling	F

Table (2): Data and product processing time

No	Work Stations	Processing Time
1.	RM	3360 minutes
2.	PR	840 minutes
3.	CC	840 minutes
4.	MP	1260 minutes
5.	PFJ	420 minutes
6.	MR	1260 minutes
7.	MO	840 minutes
8.	PL	420 minutes
9.	PR	1680 minutes
10.	CC	1260 minutes
11.	R	420 minutes
12.	S	1260 minutes
13.	F	840 minutes
	Total	**14.700 minutes**

It is known that the available production time per day is 7 hours = 420 minutes and production requires 14 units as output every day.

- Calculate the cycle time - the maximum time at which a product can be available at each work station if the production level is reached.

$$c = \frac{prduction\ time\ per\ day}{unit\ produced\ per\ day}$$

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$$c = \frac{420\ minutes}{14\ unit} = 30\ minutes\ per\ unit$$

- Calculate line balance efficiency:

Efficiency :

$$c = \frac{\sum ti}{NC}$$

$$c\frac{14700\ minutes}{6\ stations \times 30\ minutes} = 81.6\ \%$$

Thus based on these calculations it can be seen that the level of efficiency at work stations has reached 96.6%. To improve efficiency, some tasks need to be divided into smaller elements and transferred to other tasks. This facilitates a better balance between work stations and results in higher efficiency.

b. Designing the process layout to determine the total movement between work stations.
The layout of the FJLB (finger joint Laminating Board) product layout:

Figure (1): FJLB product layout flow

WRM (1)	KD (2)	DRM (3)	PR (4)	CC (5)	MR (6)
PFJ (7)	MO (8)	PL (9)	R (10)	S (11)	F (12)

100

Table (3): number of work station movements

Process/ Department	Time (day)											
	WRM	KD	DRM	PR	CC	MR	PFJ	MO	PL	R	S	F
WRM		15										
KD			15									
DRM				5								
PR					3/3							
CC						3				15		
MR							4	4				
PFJ						3						
MO									15			
PL				50								
R											5	
S												5
F												

a. Layout analysis of material movements can be calculated:
C = total movement
n = total number of workstations and departments
i, j = each department,
Xij = amount of distance moved from department i to department j,
Cij = movement to move from department i and j

Material flow is assumed that the two contiguous departments (such as WRM to KD) are 10 feet apart. Whereas non-contiguous departments (such as CC to R) are 20 feet away.

Note: here 10 feet are considered as 10 cost units, 20 feet as 20 cost units.

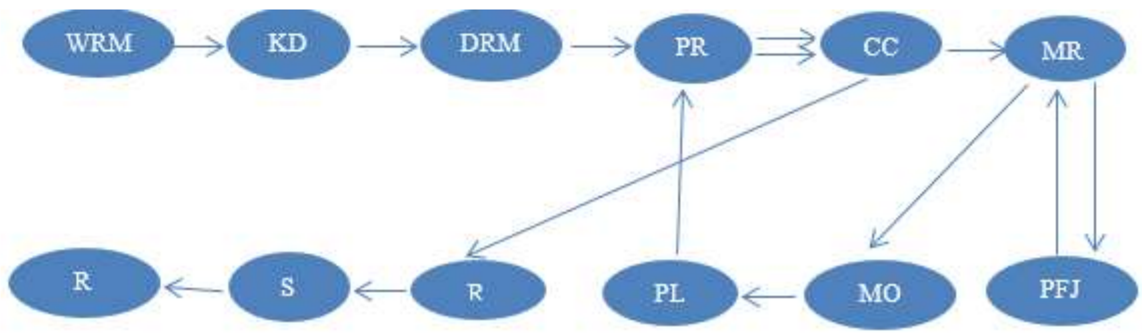

Figure (2): current material flow of FJLB products

Total movement = (15x10) + (15x10) + (5x10) + (3x10) + (3x10) + (4x10) + (3x10) + (4x10) + (15x10) + (50x10) + (3x10) + (15x20) + (5+10) + (5+10)
= 150 + 150 + 50 + 30 + 30 + 40 + 30 + 40 + 150 + 500 + 30 + 300 + 50 + 50
= **1600 feet**

Then put forward a layout plan that will reduce the current figure of 1600 feet. By approaching departments that are scattered and have long distances. Then the CC department is taken close to the R department so the distance is no longer scattered.

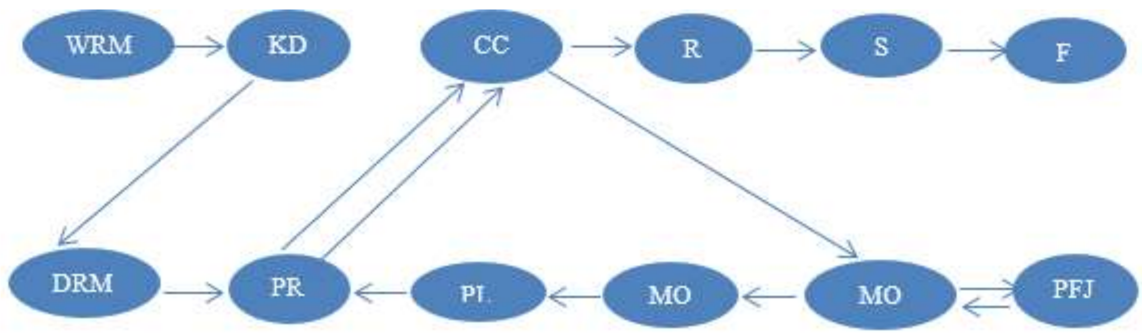

Figure (3): flow of FJLB product material after

Total movement = (15x10) + (15x10) + (5x10) + (3x10) + (3+20) + (4x10) + (3x10) + (4x10) + (15x10) + (50x10) + (3x10) + (15+10) + (5+10) + (5x10)
= 150 + 150 + 50 + 30 + 60 + 40 + 30 + 40 + 150 + 500 + 30 + 150 + 50 + 50
= **1480 feet**

Here it can be seen that there is a reduction in total movement. That means that the layout of the machine or department influences the cost and working time so that it can streamline costs and work time. To make product movement more efficient, the company must add one machine that does two repetitive works, namely on the machine (CC, MR, PR) so that it can save material handling costs.

IV. DISCUSSION

PT. Sekishin Farina Wood Indonesia is a company engaged in the wood processing industry (wood exports). This company exports wood to several countries in Europe and Asia such as America, Japan, etc. The process of processing wood from sawn timber forms into wood profile or molding wood. There are several types of products such as ABC / Raamhout Profile. ABC Finger Joint, ABC, Skeleton W. Primed, Laminating Board, Door Stick / 5 layer.

Then in the manufacture of products, there are several processes that must be passed to make an output product output that is divided into several production processes/machines such as kiln dry process, planer machines, crosscut machines, ripsaw machines, molder machines, finger joint machines, laminating machines, processes repair, sander process, and finally packing and labeling. All are arranged according to the layout (layout) that is in the company. Process-oriented layout (process-oriented layout) can handle a variety of goods or services simultaneously. This is a traditional way to support a product differentiation strategy. This layout is most efficient when making products that have different requirements or when handling customers. Process-oriented layouts usually have low volume characteristics with the highest variation. the Product-oriented layout is the arrangement of machines, facilities, and production equipment according to the work order to complete the manufacturing of a product or service to be submitted. The units produced will have the same processing sequence. This layout is organized around the same high-volume and low-volume product or group of products. Repeated production. The following assumptions are used:

a. The volume is adequate for high utility equipment.
b. The demand for its products is stable enough to guarantee a large investment for special equipment.
c. Its products are standardized or close to a phase in its life cycle that guarantees investment in special equipment.
d. The process layout minimizes material handling costs within the narrow space of the business location. The product layout focuses on how to reduce waste and imbalance on the assembly line. Work cells result from the identification of groups of products that justify special configurations for machines and equipment that reduce material mileage and regulate imbalances in cross-trained workers.

Often, the scope of layout problems is very broad so finding an optimal solution is not always possible. Therefore, even though research efforts to find optimal solutions have been made, making decisions on the layout remains an art in itself. The supply of raw materials and components is sufficient and of uniform quality (sufficiently standardized) to ensure that they can be carried out with that particular equipment.

In figure (3) shows a solution that does not violate the order requirements and classify the work in six stations. To get this solution, activities with the most advanced tasks are transferred to the work station to use as much as possible the 30 minute cycle time available.

The first work station takes 30 minutes and does not have free time, the second work station groups two tasks and balances time by 30 minutes perfectly. The third work station classifies two tasks (MP and PFJ) and still has a free time of 4 minutes per cycle. The fourth station groups two tasks (MO and PL) and has a free time of 5 minutes per cycle. The fifth station takes 30 minutes. And the sixth station groups four tasks and balances time by 29 minutes and has 1- minute free time. The total free time for this solution is 10 minutes per cycle.

V. CONCLUSION

In this paper we have shown that the quadratic task problem approach can be used to solve layout design problems for flexible manufacturing systems, even when machines do not have the same size. The two most common cases, loop-conveyor and linear-track conveyor systems, are considered. Computational testing shows that this method works. Several solution approaches are recommended for solving large size problems, however, single, multi-line, or loop layouts in modern manufacturing facilities may not contain large amounts of machinery.

The number of machines in a cell or line on the facility floor is usually small as observed by Kouvelis and Kiran (1992), and Askin and Chiu (1990). As such, it might be more appropriate to utilize the computational time spent on solving large size problems in developing layouts for a small number of machines that include other features of the engine layout problem. Simulated annealing (SA), it is recommended to develop the engine layout. However, the solution obtained from SA does not seem to be far superior to the solution obtained from a simpler approach.

Furthermore, SA requires sufficient computational time to determine the appropriate value for its parameters and to develop the layout, but so far it has not added to the understanding and content of knowledge of engine layout problems. The study of SA parameters and their theoretical aspects in the context of engine layout may be needed. Furthermore, SA-based procedures must seek to exploit the layout structure of the machine to reduce the computational burden of this approach.

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