Reduction Effort of *Motion Waste* in a Test Room of Component Products

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Abstract: The research's goal is to reduce non-value-added motion or activity of a production process, which can be classified as a waste in a production process. The research is done in test room. Non-value-added motion or activity can reduce productivity and slowing production process. Improvement proposal of this research consist of re-layout proposal of test room and implementation of kaizen in test room. Improvement of re-layout in test room resulting in a better design of layout, showing result of reducing total travel distance of material in testing process. The new layout showing moment calculation result of 107196 meters, while the old layout's result is 153856 meters. Based on the result, the new layout implemented in test room. Kaizen implementation in test room is done by creating visual control, improvement implemented by creating boundary line of object in test room's workplace. Improvement also done by creating a place for storing any tools and equipment that support testing process, with refers to the concept of kaizen foam.

Keywords: Facility Design Layout, Moment, Kaizen, 5S, Visual Control.

Introduction

Testing process inside a testroom is consist of function sorting, which is sorting the finished product, and AQL sorting before entering packaging process. The product is one of the superiror product in the company, but there isn't any attempt to reduce motion waste in the testroom. Some of the problem such as layout problem, working methods, standardization, and discipline in work are interesting aspect to be researched in reducing motion waste in test room. This research's goal is to reduce motion waste in test room.

Methods

Facility Design Layout

Layout is one of the important aspects that exist in the industrial world. The layout of a plant (plant layout) or commonly called the facility layout can be defined as the procedures for setting factory facilities to support the smooth production process (wignjosoebroto, 2009 [1]). The layout in an industry will organize two things, the setting of the machine (machine layout) and the setting of the existing departments in the industrial/plant (department layout).
The layout setting at a factory or industry can be done in two things:

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setting of existing layout or setting new layout. Good plant layout will provide benefit in efficiency and in some cases will also maintain the viability of an industry or the success of an industry.

Sophisticated equipment as well as a good product design will be nothing without having a good layout design. An industrial production activity is always associated with a layout that does not change, so if there is any error in designing facility layout it will lead to the huge amount of loss. The main objective in designing facility design layout is basically to minimize total cost which can occur involving element cost such as:

a. Construction and installation cost, either for bulding, machines, or other production facilities.
b. Cost of moving material (material handling costs).
c. Production cost, maintenance, safety, and work in process product inventory.

Optimal facility design layout can also provide convenience in supervision process as well as facing the plant expansion plan in the future (Wingjosoebroto, 2009). The purpose of planning and designing facility layout can also provide several benefit such as:

a. Increasing production output, good layout will provide a greater output result with the same cost or even less.
b. Reducing waiting time.
c. Reducing material handling process, a good layout will reduce or minimize activity in material handling.
d. Saving the use of area for production, warehouse, and service.
e. Optimizing the using of machine, workforce, and other production facilities.

f. Reducing work in process inventory.
g. Shorter manufacturing process.
h. Reducing risk for health and safety of an operator.
i. Improve morale and job satisfaction
j. Make supervison activity easier.
k. Reducing congestion and the maze of material.
l. Reducing factor that could harm and affect the quality of raw materials or finished products.

According to Heragu (1997 [2]), the calculation of moment can be used to determine the cost of moving material ccurring in a layout. Calculation of momen is done by using the following formula:

$$\text{Momen} = \sum_{i=1}^{a}\sum_{j=1}^{a} Flow\ Material\ x\ Distance \quad (1)$$

Where:
Dij Is the distance between facility i and facility j
Fij Is the flow or movement of material between facility i and facility j.

Activity Relationship Chart

Planning the layout or planning in determining a good layout is fairly important part in designing the layout of a facility (Heragu, 1997). One of the important part in planning is to know the relationship, or the relationship of each existing facilities. Knowing the relationship of each facilities is served as the measure used to determine or qualify the interaction between departments or facilities that exist in planning the layout of the facilitiy. Relations between the facility and the department can be determined by using the Activity Relationship Chart or hereinafter reffered to as ARC Chart. ARC Chart will use the codes in the form of letters that will map the level of releation between one facilities to another. Table 1 shows the letters code used in the ARC Chart.

Table 1. Letters code in ARC Chart

Letter Code	Closeness Relationship
A	*Absolutely necessary*
E	*Especially important*
I	*Important*
O	*Ordinary*
U	*Unimportant*
X	*Undisireable*

Letters code shows the degree of importance for assigning a department with a specific code. A letter code is a code that has meaning between two facilities should be adjacent (absolutely) and weighs a value of four. E letter code has an especially important closeness and weighs a value of 3. I letter code has important closeness and weighs a value of 2. O letter code has ordinary closeness and weighs a value of 1. U letter code has not important closeness, so that between one facilities to another is not essential to put adjacently or it is just ok wether those two facilities put adjacently or not. X letter code has meaning of not important closeness means other facilities should be kept away from one's facility and weihgs rating value of -1.

Activity Relationship Diagram

Activity Relationship Chart can describe the relationship between facilities using Activity Relationship Diagram or hereinafter referred to as ARD. Analysis of layout design with referring to the degree of closeness is one of the important thing to be considered further. Activity Relationship Diagram made after the Activity Relationship Chart is done. Symbols and colours used in making and serving Activity Relationship Diagram can be seen in Table 2.

Table 2. Symbols and colours in *Activity Relationship Diagram*

DEGREE OF CLOSE-NESS	DES-CRIPTION	LINE CODES	COLOR CODE
A	Absolutely		Merah
E	Especially Important		Oranye
I	Important		Hijau
O	Fair		Biru
U	Unimportant	Tidak ada kode garis	Tidak ada kode warna
X	Undesireable		Coklat

Lean Manufacturing

Lean is a continuous effort to elimane waste and increasing the value added of a product, goods and/or services in order to deliver value to customers (Gaspersz, 2007 [3]). Lean manufacturing can identify and eliminate activities that do not give value added by doing continuous improvement. Continuous improvement means improvement to the process or timeline between customer orders with delivery times by eliminating activities that do not add value (Taiichi, 1998).

The goal of lean is to create a smooth flow of products throughout the value stream and eliminate all types of waste that exist. A company will be able to increase production by eliminating or reducing activities that do not give value added or considered as waste. Waste is activities that do not give any benefit (value added). Waste can be defined into seven types such as transportation, inventory, motion, waiting,

over-processing, over production, and defect. Increased productivity will be achived if it can reduce or eliminate such waste. To eliminate waste in lean manufacturing can be achieved in some ways, they are:

Kaizen

Kaizen can be defined as carrying out small improvement activities in a sustainable manner used by many Japanese companies (Monden, 1995). Kaizen or commonly reffered to 5S is the method used to reduce existing weakness in the plant (Monden, 1995). 5S is an abbreviation of the Japanese words, they are Seiri, Seiton, Seiso, Seiketsu, and Shitsuke which overall summarized into a cleanup acivity in the workplace.

Cleaning intended in the factory is the reduction of the goods in the processing or work in process (WIP) unnecessary products. WIP items that are not required may be leftover paint, malls, tooling, gauges are not required, used oil, trains, fixtures, tables and others that are not needed. The implementation of 5S, quality level, time of booking, and cost reduction can be repaired, this is what is referred to as the three main objectives of production management. Hiroyuki Hirano believe that by introducing 5S, a factory can supply products that customers want, in a good quality, low cost, fast, and secure so that corporate profits will increase. Five components of the 5S is defined as:

a. Seiri
   Seiri in Indonesian can be interpreted as sorting objects which are not needed can be removed. Practice to apply seiri done by using the label in red rectangles so that only the necessary items that will remain in the plant. Professor Yuji Aida of Kyoto University running a sorting process called Aida method which saves an item or information by not distinguishing interests but only add jobs. This makes the necessity to throw everything unneeded items (Osada, 1995 [4]).
b. Seiton
   Seiton in Indonesian which means tidy, is the process of drafting or arrangement with a neat and marking objects to make use of objects easier. Structuring goods means storing stuff with attention to efficiency, quality and safety as well as finding ways op-timal storage (Osada, 1995). Understanding Seiton literally means arrange the various objects in interesting ways. Seiton in the 5S concept means arranging things so that everyone can find it quickly. Sign board is used as a tool to establish the name of each item and its storage place (Monden, 1995). Stages in Seiton activity is to determine the place for items appropriately, and then determine how to store the goods. Rules to always keep returning goods to the same place should always be obeyed so that these activities always run continuously (Osada, 1995).
c. Seiso
   Seiso in Indonesian means cleaning is an activity to always clean, maintain neatness and cleanliness. Seiso is a basic cleaning process in which a swept area then mopped with a mop. The company must be cleaned every day including the floor, the windows, and the walls to avoid engine damage caused by oil spills, ash, dust, or trash. Cleaning means more than just making the goods to be clean, but a commitment to be responsible for all aspects of goods used to make the goods in prime condition. Possibility of stuff jammed, disability, or an accident can be caused by dust, dirt, foreign material, the sound of a loud engine noise, therefore routine cleaning should be done to avoid it.
d. Seiketsu
   Seiketsu in Indonesian means the consolidation of which is a continuous activity to maintain seiri, Seiton, and Seiso. Stabilization means maintaining a clean state which includes other considerations such as color, shape, clothing, etc., that provide a clean atmosphere (Monden, 1995 [5]). Consolidation is also regarded as a repetition of sorting, structuring, and cleaning as well as awareness and activity so that the state of 5S is still maintained. Activities in Seiketsu can usually be maintaining the workplace in order to keep it clean without waste or oil droplets (Monden, 1995).
e. Shitsuke
   Shitsuke in Indonesian means habituation is a method to make workers accustomed to obey the rules that have been made. Habituation is doing the job repeatedly so naturally can do it right. 5S concept will not succeed in the absence of habituation, since this is a way to change bad habits become better (Osada, 1995). Dr Eizaburo Nishibori (1985) says that Shitsuke is the most important thing in the implementation of 5S, therefore the people who teach new workers have to give good example. Workers must be used to place objects nearby to simplify taking of goods. Workers who have 5S knowledge alone is not enough, but should practice the many times that it becomes a habit spontaneously, of his own volition and not because of forced (Monden, 1995).

Result and Discussion

Test room is part of the production process in the company and is the final step before the product can be packaged, the entire product will be tested in this test room. The product will be tested whether all of

them meets the standards and regulations that exist before being packed and shipped to customers. Activities that occur in the test room includes testing a trip time range of products and AQL testing before being packed. Until now there has been no improvement efforts are being made to improve the efficiency, and the reduction of waste motion of the testroom. Several improvement efforts conducted in a testroom are described in the next section

Perbaikan Layout Ruang Uji 1170

Improvements made to the machines and other test room facilities only, while the laser machine is still part of the production segment that is not included in the repair. The layout of the test room will be mapped prior to the activity relationship chart to determine the degree of importance of the relationship between existing facilities in the test room Acivity 1170. Chart Relationship Chart can be seen in Figure 1

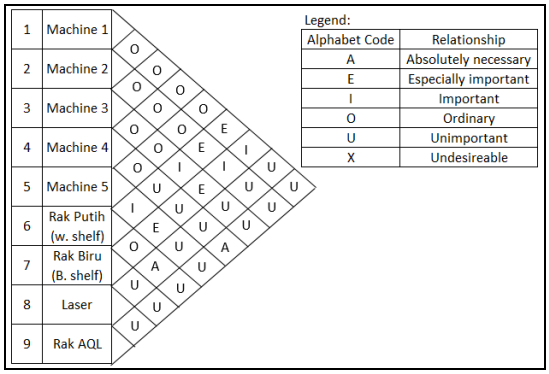

Figure 1. *Activity relationship chart* of the test room

Mapping the degree of relationship between the existing facilities in the test room will be mapped to the Activity Relationship Diagram (ARD) to be able to know the better layout for test room. Mapping into ARD is expected to know the layout of the good facilities in accordance with the needs of each of the existing facilities. ARD of the test room can be seen in Figure 2

Figure 2 shows that there are still some facilities that have a relationship that is quite important, but located far apart. Improvement proposal of facility layout will use the degree of relationship between the facilities as a reference in designing the layout of proposal improvement in the test room. Improvement proposal of the layout of the test room also adjust the existing limitations they are the location of the electrical terminal for a particular machine that does not have a cable long enough to reach the electrical terminal.

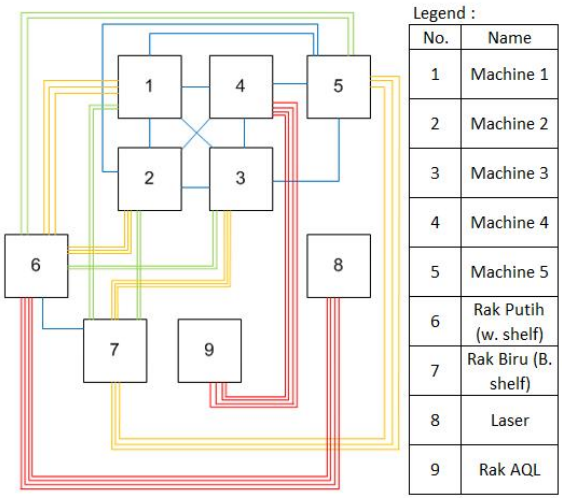

Figure 2. *Activity relationship diagram* of the test room

The layout in test room feel cramped in some places and not efficient material flow streams. Some machines that exist in the test room is located at the very end, but require the goods on the shelves are located on the side of the other end of the room. Long distances and must pass through a narrow area considered to be ineffective for the smooth flow of material. Material flow that occurs in the test room will be displayed in the test plan space before and after improvement.

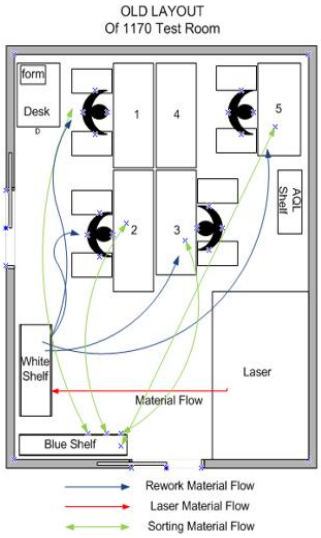

Figure 3. Layout of test room before improvement

Figure 3 shows that Material flow came from area of the laser machine to get to the white shelves, then the material will be taken by each operator on every machine that is in charge of sorting. Material flow also occurs on machines that do rework, the operator will take the material from the blue shelves which is a waiting for adjust shelves to cool down before retested. Material flow occurs intersecting (cross-movement)

between the flow from the laser towards white shelves and shelves of the testing machine towards the blue, while access to the engine 3.4 and 5 must pass through a narrow area to reach the shelves of white and blue.

Ineffective material flow as well as the placement machine and a rack far enough is a problem that occurs in this test room. There has been no attempt to improve the layout from the test room until today. Layout problem contained in the test room can be overcome by changing the existing layout now in order to be more efficient and effective in performing a series of testing process. Proposed improvements to the layout of the test room can be seen in Figure 4.

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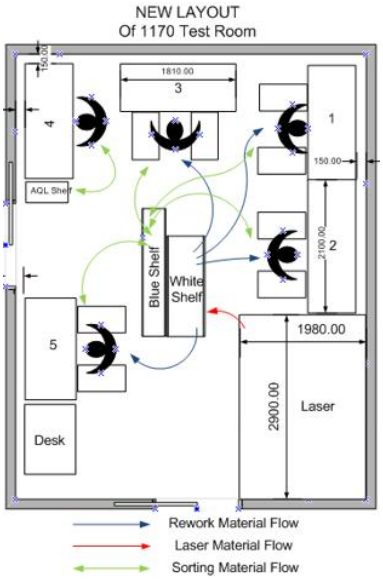


Gambar 4. Layout of test room after improvement

Improvement proposal layout from the test room has the goal of efficiency of material flow, the material displacement distance is shorter or closer. Structuring the location of facilities that surround the rack allows the operator to be able to more easily reach the shelf where the material to be used, so that the material flow is more efficient. Material flow crossing each other or cut (cross-movement) do not happen again, because the rack is placed in the middle of the room and the whole machine surrounds the rack. The new layout in the test room is based on the relation between the machine with the rack, which is closer to the machine that has a specific task with a shelf that contains the material to be working on

Machine 1 and 2 is a machine that has a major task to sort so that brought closer to the white shelves which is where the material that has not been tested. Machine 3 and 5 is the the machine that has the task to work on the product rework, so that brought closer to the blue shelves which is a rework material is placed. Machine 4 is a machine that has a duty to AQL testing, so that shelves to wait for incoming AQL products placed next to the machine.

New layout proposal of test room will be proven technically whether it is better from the previous layout or not, by performing the calculation of moment. Calculation of moments performed both on the test room before the improvement and after the improvement, to determine whether the improvements made a positive impact or not.

DISTANCE		Mesin 1	Mesin 2	Mesin 3	Mesin 4	Mesin 5	Rak Putih	Rak Biru	Laser	Rak AQL
From/To		1	2	3	4	5	6	7	8	9
Mesin1	1		0	0	0	0	7	7	0	
Mesin2	2	0		0	0	0	5	5	0	
Mesin3	3	0	0		0	0	7	8	0	
Mesin4	4	0	0	0		0	9	10	0	4
Mesin5	5	0	0	0	0		10	11	0	
Rak Putih	6	7	5	7	9	10		2	5	
Rak Biru	7	7	5	8	10	11	2		5	
Laser	8	0	0	0	0	0	5	5		
Rak AQL	9				4					

Flow (pcs)		Mesin 1	Mesin 2	Mesin 3	Mesin 4	Mesin 5	Rak Putih	Rak Biru	Laser	Rak AQL	
From/To		1	2	3	4	5	6	7	8	9	MOMEN
Mesin1	1		0	0	0	0	0	100	0	0	700
Mesin2	2	0		0	0	0	0	100	0	0	500
Mesin3	3	0	0		0	0	0	100	0	0	800
Mesin4	4	0	0	0		0	0	0	0	32	128
Mesin5	5	0	0	0	0		0	100	0	0	1100
Rak Putih	6	3000	3000	3000	0	3000		100	0	0	87200
Rak Biru	7	100	100	100	0	100	100		0	0	3300
Laser	8	0	0	0	0	0	12000	0		0	60000
Rak AQL	9	0	0	0	32	0	0	0	0		128
											153856

Gambar 5. Perhitungan momen pada layout awal

Figure 5 is the moment calculation in the original layout. The same calculation is done on the new layout after the improvement suggestion. Calculation of moements on the layout before the improvement resulting in a number of 153,856 meters. Calculation of moments on the new layout resulting in lower amount of moment than the original layout. Moment calculation in the new layout resulting in a number of 107,196 meters. Smaller moments have the meaning of shorter travel distance of a product in a particular time. The improvement proposal in the test room also provides benefits that refers to the principles of the layout of the facility, that is the principle of minimizing the displacement distance of the material.

Penerapan 5S pada Ruang Uji 1170

DL and UL Machine is the a machine that is devoted to the DL and UL testing on the product, so that the machine is not assigned to perform testing sorting and rework. Lack of discipline can be seen when doing the test, the goods do not neatly arranged and tools that should complement the testing process is not in place. A tool such as a timer should be on the machine table to signify when the time has passed 3600 seconds to check wheter the test is succeed or not. Waste of time occurs when operators are aware

if a test has been completed and the product sit still in the machine for 5 minutes. The idea of improvement to be done is to make the area for laying materials and tools supporting the test on the machine clearly. Improvement proposal were made by splitting the area in two section as it should be, between a product that has not been tested and already tested product in order not mixed. Design of the workplace using these methods can be seen in Figure 6.

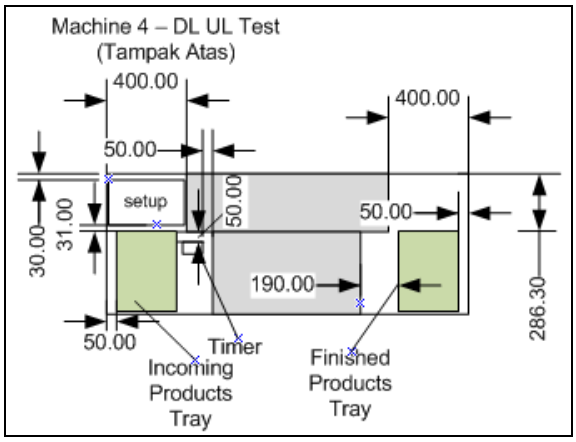


Figure 6. Improvement proposal of *workspace* in DL and UL Machine

Material that will be used are transparent acrylic which will be given lines of brightly colored marker area that will be laying objects on the desk. The expected goals from this proposal is to create a compact work area and tidy, as well as ensuring the tools needed to remain in place through visual control.

Improvements to the work area can also be done on the place to put the equipment and fittings that are used to support the work activities. Equipment and fittings such as screwdrivers, pens, markers, staples, and the label should be in the same place so as not to lie messy in the work area. Equipment and fittings that are not present in place will make the operator looking for the object when those objects are needed. There is no special place for all equipment for this testing process yet, there is only one the machine at this test room which has a simple container or tray. Container or place for such equipment and fittings in one work area can be seen in Figure 7

Existing containers can not accommodate all the equipment well, so some of the tools and equipment still laying outside the tray or container. The container for tools and equipment has goal to contain every tools and equipment in the same one place, therefore it is easier to be used by the operator. The beasis in creating the container refers to the concept of 5S visual control using kaizen foam. The use of visual control will help the operator to know weher is the location and number of each object, a standard procedure to do a job, the status from work in process goods, and other critical information (J.K. Liker, 2004 [6]).

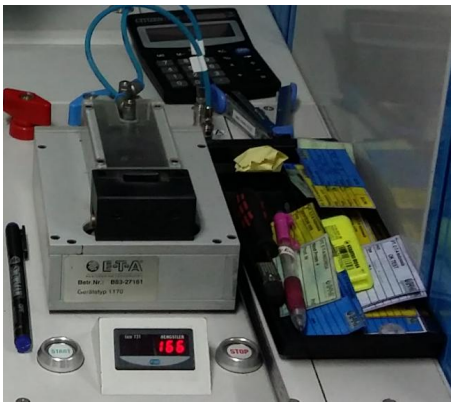
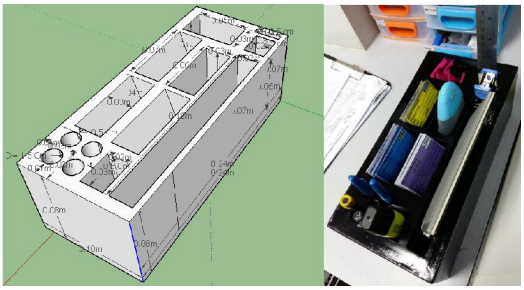


Figure 7 Container of tools and fittings before improvement.

Clear standards, putting objects in the space provided and make it visually it will be easier for the operator and manager to find out if there are objects that are not in place. Improvements carried out by first sorting the objects that are not needed in the work area, as well as classifying objects needed. The proposed draft has the goal of keeping the availability of a container that is neat and compact for equipment and fittings that support the testing process. The design from the container and the completeness of testing equipment can be seen in the drawings in Figure 8.



Gambar 8. Design of tools and fittings in testing process (left) and the implementation of the design (right).

Container of equipment and fittings of this testing allows the operator to find the entire supporting tools in testing, both of which are needed before and after the product testing process. Tools and fittings in the operator's working area will be detected easily if not in place, because every object has had its own place. Discipline must be applied in realizing part of the 5S, the operator should immediately return the object in place after use. Training and direction for all opera-

tors can provide insight and improve the level of discipline of each operator.

Conclusion

The conclusions that can be drawn is an attempt to reduce motion waste in the test room can be done by several methods. The first method used to reduce motion is to change the layout of existing facilities in the test room. Moments obtained in proposal layout of the new facility shows the value of 153,856 meters, while the value of the moment on proposal new layout has a value of 107,196 meters. The second method is carried out to reduce motion in the test room is to implement kaizen or 5S. Improvement is done by making the visual control on the test room also creating a special container for the tools and equipments or fittings in test room.

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