Green productivity methodology for furniture industry

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Abstract. This project presents the implementation of green productivity methodology for furniture industry. The main issue in furniture industry is reducing environment pollution and industry waste. The objective of this study is to apply and implement the green productivity methodology in furniture industry to carry out the environment and waste problems. The green productivity utilizes three tools, specifically material balance, eco-mapping and plant layout. Through the analysis results of material balance, the majority of production wastes were sawdust and a small piece of woods that cannot be exploited again. Instead of being burned, it will be preferable to be accumulated and sold it at the market. With eco-mapping analysis, it can be recognized about which area that produced the most substantial amount of wasted pieces. Hence, the remaining of sawdust will also be collected to be sold. After that, the proposal of the plant layout has been established with the consideration of production scheme and also the distance between all stations will be closer than before. The plant layout chosen is the first of proposed plant layout because it has the shortest production flow distance, which is 49.5m, which can intensify the efficiency of 160% from the original layout. Besides of the reduction industrial waste of this workshop, the company productivity is increased and obtained the additional income as a consequence of invaluable waste at first, to be processed to gain value-added.

Keywords: Green Productivity, Furniture, Industry Environment

1. Introduction

In this era of globalization, industrial sector is experiencing a rapid increase in many countries, including Indonesia. In Indonesia, increasing in oil and gas industry as well as non-oil and gas should be reduced until 20% [1]. The efficient growth of this industry’s activity will give positive and negative effect indirectly. A short perspective criticize from the positive effect, industrialization was one of the incentive circumstances to modernization that was supposed to intensify the society sustainable level. In contrast, the negative impact is pollution caused by industrial activities such electricity generation as urbanization process, environmental pollution, consumerism of society, the reduction of agricultural land and industrial waste [2-4].

Nowadays, the challenge in the industrial section is executed dynamically, and it is followed by various kind of pressure such as globalization of world trade, standardization and government regulations. Previously, operation system focused on low expenditure, but many people currently consider having the operation system that is sensitive to environmental matters, for instance, utilizing...
eco-friendly machine and exploiting raw materials that can be recycled. Therefore, green productivity concept is applied to respond to the recent problems [5-6].

Another approach has been introduces the green productivity as a strategy to enhance productivity and environmental performance that can provide positive changes in the socioeconomic field [7]. This aims in covering all aspects of socio-economic development that lead to the improvement of life’s quality for human. This productivity is a combination of all application from the tools, techniques, and technology and appropriate productivity which intends to reduce the environmental impact of organizational activities, products and services while increasing the profitability and competitive advantage [8].

Green productivity is a strategy to enhance productivity and environmental performance that can provide positive changes in the socioeconomic field. Green Productivity can be defined as Eco-Friendly Productivity. It is a part of the improvement program of eco-friendly productivity in order to respond to the global issue about sustainable development. Green Productivity is related to the combination of appropriate application of tools, techniques, technology, productivity and environmental management in reducing the negative environmental impact caused by organizational activities. Green productivity fulfils the society needs to have a better quality of life by enhancing the productivity through manufactures and eco-friendly management activities. Moreover, green productivity also responds to the global issue about sustainable development. The concept of green productivity focuses on 2 important things, which are the enhancement of productivity and the environmental protection [7]. There are 12 tools used in implementing green productivity, which are material balance, material flow cost accounting, eco-mapping, energy balance, work sampling, cause & effect analysis, cost & benefit analysis, bench marking, Pareto diagram, Ishikawa diagram, control charts and failure mode & effect analysis [8].

Wastes can be defined as all working activities that do not offer any additional value in the process of transforming input into output throughout the value stream mapping. According to lean perspective, all types of waste when transforming input into output in the value stream process must be eliminated in order to increase the product value (goods or services) and the customer [9]. Seven wastes are classified into 3 main categories, which are man, machine, and material. The category of man comprises the concept of motion, waiting and over production. The category of machine comprises over process while the category of material comprises transportation, inventory and defect [10]. By optimizing the facility layout is one of the solution in increasing the productivity performance [11], particularly for robust facility to fulfil the product demand uncertainty [12].

At this moment, furniture industries have been found several problems in reducing the waste as the result from production. Therefore, this study applies the Green Productivity (GP) methodology to carry out the current problems. In addition, most of activities in furniture industry from warehouse and production is analysed and proposed using GP methodology particularly in the aspects of material balance, eco-map, and plant lay out.

2. Materials and Methods
In general, the furniture industries have similar in term of process and lay out. In this study, the data was collected using observation and interview to relevant workers. A furniture company which located in remote area of Jakarta, Indonesia is selected as a case study at workshop, there were many piles of unused goods which disturbed the work progress as shown in Figure 1. It is found that, the current lay out is potentially to be investigated due to improper placement.
Figure 1. Front look warehouse area

The work area is also separated from a considerable distance, making the production flow ineffective. It is defined by the Figure 2.

Figure 2. General plant layout at furniture industry

In addition, there is a combustion process that results from the residual production that is carried out every week, causing environmental pollution. In this study, Green productivity was implemented in the company in order to enhance the productivity and reduce the waste by utilizing several tools such as material balance, eco-mapping and plant layout.

The current layout is identified using diagram relationship space (Figure 3) in order to show the level of importance between areas or departments.
3. Results and Discussions

Base on the space relationship diagram and current layout, the lay out proposal are generated. There are two alternative solutions for layout. As shown in Figure 4 and 5, the first proposal layout is made by following the production flow process. The cutting area is placed into one section, measuring 10m x 18m. All employee areas and toilets are moved to the right side of the workshop, replacing the original place for the process of cutting and extension from the finishing place. Then, assembly and warehouse finished goods are separated, this is to facilitate work and make materials flow in the same direction. The left upper area of the workshop is used as an assembly place, measuring $14 \times 7 \text{ m}^2$. Then a door with a width of 3 m is made to get into the painting area through the top.

![Figure 3. Space Relationship Diagram](image)

There is no change in the painting and finishing area, only the finishing area is minimized. Then, at the bottom of the finishing place, placed a door with the size of 2 m, so that the finished goods can be directly transferred to the warehouse finished goods section. Motorcycle parking is also expanded, so that it can meet existing capacity.

The warehouse area is moved next to warehouse raw material, because the warehouse contains paint, which is used in the painting area. Moving the warehouse next to warehouse raw material will significantly reduce material flow. The office area is not moved, so it is easy to oversee the finished goods, and is closer to the office area, employee residence and toilet.
In the second proposal layout plant (Figure 5), identical with first proposal layout, the assembly area and finished goods warehouse which were initially put together, were separated into their respective areas. The second proposal focuses on the right side of the workshop as a production process. First, the employee's residence is moved to the top left. Then, warehouse raw material was moved to the area next to the office, along with the warehouse.

The cutting site has an area of 10.5 × 16 m² right in front of warehouse raw material. Then, make a door at the right end of the cutting area, so that the items can be moved to the next area; the assembly area. The assembly area replaces the finishing area, which is moved to the left side of the workshop. Then, the product is brought to the left to be painted in the painting area. The lower part of the painting area is a door with a width of 3m. Then, the finishing area that is located on the left side of the shop, next to warehouse finished goods. After the product is produced, it is then stored on the left side of the finishing area. The material flow in the second proposal is less effective compared to the material flow in the first proposal.

To choose the best layout that must be applied for furniture industry workshop, it is required the strengths and weaknesses of each of the previous layouts. In the initial layout, the shortcomings were too many piles of unused items which disrupted the production process, as well as work stations that were not in line with the production process flow, resulting in a cross movement that caused waste to occur in motion and transportation. Then the best solution for layout is chosen by considering total length of material handling as shown in Figure 6.
Through those three layout above, the total production flow in the initial layout is 129.1 m, the first proposal layout is 49.5 m and the second proposal layout is 71 m. Therefore, the redesign of factory layout and facilities from Furniture industry selected is the proposed layout 1, with a material handling path length of 49.5 m. This result is 160% more efficient compared to the initial layout.

In order to understand the wastes that is produced from a production, the material balance for selected furniture industry tools are utilized (Figure 7). The result is demonstrated one of the Green Productivity tools and technique that initiated by Asian Productivity Organization (APO), 2018 [7].

As result in selected furniture industry, it was received an order of 30 pcs of mobile pedestal with a size of 30 cm x 50 cm x 20 cm. After going through a series of input and output production process, the wastes produced became wood powder and small pieces of plywood. This type of waste will be the main discussion in this report. In production process, wood powder and small woods that derived from the cutting process would be collected and burned at the back of the workshop every 1-2 weeks. To figure out which areas contained waste production, this eco-mapping is prepared and created according to what is shown in Figure 8. This eco-mapping result agreed with the expected outcome of using Green Productivity from APO, 2010 [8].
production area has 5 parts, which are cutting, painting, assembling, burning and finishing. The storage area is divided into 3 parts, specifically storage of raw materials and storage of finished goods and warehouses.

Then, the part that has potential to become waste is symbolized by a red circle with a dashed-line next to the top right corner. The discussion will start from the employee area. In this employee area, it is categorized that potentially could cause waste. This employee area is occupied after they settle their work to take a rest. From 30 to 40 workers, there are usually 10 to 15 people who take a rest or remain to stay, sleep there. Waste that arises, comes from electricity expense, for instance televisions, air conditioners or chargers, as well as the waste from water and plastic waste or leftover food-waste from consumption.

In the storage area, both raw material storage and storage of finished goods have no potential to cause waste, because its usefulness is only to store goods without further activities. In the office area, it also has the potential to cause waste even if it only affects some circumstances. This is because of the office space is rarely occupied that indicates most general managers are in the field and the owner comes only once a week on Fridays. Waste that may appear only comes from air conditioners in the room and electricity used to use computers.

In the production area, all parts probably might cause waste. The cutting section is definitely related too preparing plywood or melamine from standard sizes to the pieces needed to fulfil customer demand according to the work drawing. The cutting process at selected furniture industry is still semi-manual that can be proven when workers still utilize a chainsaw in cutting process. Wood powder will appear as a result of the cut. In addition, small amounts of wood will appear as the remainder of the main wood cutting.

Those woods which will be eventually burned in the combustion section, approximately 1-2 weeks. As a result of this waste combustion, it will cause other waste, namely smoke which can cause air pollution for the surrounding environment. Thus, from that part, the combustion also has the potential to cause waste. Then, for assembly and painting parts do not cause waste. The assembly part only combines previously cut wood, using either bolts, hinges or wood glue. In the painting section, if the customer requests a finished products that has been coloured, the product that has been assembled will be sprayed with paint. There is no waste arising from this process.

In the finishing section, there are two choices, which are coated with the method of High Pressure Laminate (HPL) or using melamine. If finishing with HPL, then there is no waste arising from this process. HPL itself is one of the finishing materials commonly used in furniture products and interior surfaces that comprises a laminate with high pressure. Along with the increasing demand from environmentally friendly materials has made HPL as one of the most popular finishing materials for furniture products. If melamine is utilized for finishing, the sanding process still needs to be accomplished. This aim in smoothing the surface and clean the wood media from dirt and wood defects through sanding process. Consequently, as a result of this sanding process, there will be woods powder arising from friction from the sandpaper.

On the contrary, the production waste in the form of wood powder and small wood is not burned, but collected, aiming in selling to the market. Wood powder still possess its sales value. Wood powder can be used as a combination of making furniture, brick making materials, fuel, pedestal for hamsters, planting media, and briquettes, and can be used in paper making. For small pieces of plywood, it should be collected together and then sold, or modified into powder form by using a wood shredder machine. This is because wood powder is much easier to sell than ordinary wood.

4. Conclusion
The implemented green productivity tools by selected furniture industry were material balance and eco-mapping to ascertain and decrease residual wastes production that were sawdust and small pieces of plywood, while the plant layout to analyse and increase productivity. Based on the length of material handling, to improve the layout of selected furniture industry is to apply the proposed plan layout 1, which is capable to increase efficiency from material flow until 160%. The best solution to
reduce wastes of selected furniture industry by changing the workshop layout with proposed plan layout 1, economizing electricity expense and selling the sawdust compared to burning it out. It can be done by transforming small plywood to sawdust with wood shredder to avoid firing process.

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