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Integration of Environmental Impact Assesment in Healthy Trolley Product Development

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ABSTRACT
The growth of green customer in the last few periods, indicate that the environmental performance of a product has become the main attributes, not just as a complement attributes to the customers. This condition encourages every industry to assess the environmental impact of the products that being marketed. Healthy trolley is a product innovation of shopping trolley that being developed using reverse engineering methods. This study aims to analyze the environmental impact of Healthy Trolley to provide an alternative product design improvements based on sustainable products concept. The method used is life cycle assessment that consist of several stages i.e., goals and scoping, inventory analysis, impact assessment and improvement analysis. Based on the results, products waste in the end of use gives the biggest negative impact on the environment and humans. The environmental impact of products derived from the constituent materials such as iron (Fe), lead (Pb) and sulfuric acid (SO4). So the alternative Healthy Trolley design improvements are replacing the drive system into manual in order to eliminate the environmental impact from waste of material lead (Pb) and sulfuric acid (SO4).
Keywords - Sustainable Product, Healthy Trolley, Environmental Impact Assessment

I. INTRODUCTION

The emergence of green customer in recent period, indicate that the environmental performance of a product has become the main attributes, not just as a complement attribute for customers. It encourages every industry to assess the environmental impact of the products that being marketed. Green product development and green manufacturing is the form of strategies undertaken by the industry to respond the customer behavior changes [1].

The evolution in product development processes occur from production-oriented approach, orientation in marketing, customer orientation and the last is sustainability orientation [2]. Sustainable product is a product that provides a positive contribution to the environment, social and economic during the life cycle of products start from materials selection, manufacturing process, distribution until the disposition phase of product at the end of its technical life.

Environmental impact assessment is done based on ecological principles i.e., energy savings and reduced environmental impact as the main focus in sustainable product development phase. One method to evaluate the systematic identification and simultaneously minimize the environmental impact of a product is life cycle assessment (LCA) contained in ISO 14040 with emphasis on product life cycle analysis. This method allow an analytical work to assess and reduce all environmental impacts [3].

Some previous studies have been conducted regarding to environmental impact assessment. An analysis on the environmental impact of products and processes of Autoliv's night vision camera in Europe using life cycle assessment method has been done [4]. Another research also used the method to develop a system that capable to minimize the environmental impact of iron and steel production in India [5]. A measurement of environmental impact has also been conducted to make improvements in the production process of soft drinks in Marocco [6].

Healthy trolley is a product innovation of shopping trolley that being developed by Manufacturing System Laboratory, Industrial Engineering Department FTI UII using reverse engineering. This product has three additional functions compared to conventional trolley i.e., keep product hygiene, such as food that are not mixed with hazardous chemical substances, flexible in use and ergonomic. By using the concept of sustainable product, it is necessary to analyze the environmental impact of Healthy Trolley product to provide an alternative product design improvements.

II. BASIC THEORY

Life cycle assessment is associated with a product, process, or activity by identifying the quantity of materials that being used, energy consumption and wastes that being release to the environment [7]. There are some positive contribution of life cycle assessment for an industry, which is able to identify some opportunities in

environmental aspects improvements at various points of a product or process, helping to provide a strategic decision to improve the environmental conditions and economic [8]. It also can be used as a basis for marketing innovations (environmental claim, eco labeling scheme or environmental product declaration).

There are four stages in the standard methodology of LCA [7] i.e,: defining the purpose and scope of the study, inventory analysis, impact assessment and improvement analysis.

a. Goal Definition and Scoping

Goal definition and scoping is the activity to set goals and scope of studies to establish boundaries, assumptions and limitations of a life cycle assessment [9].

b. Inventory Analysis

Inventory analysis is the stage of collecting and measuring data relating to the product life cycle in a unit of functions, including: input materials and energy, products, waste, and air emissions, water, and soil [10].

c. Impact Assessment

The main function of the impact assessment is to describe and analyze the potential impact. There are three stages in this process i.e., the classification, characterization, and valuation [9].

d. Improvement Analysis

This stage provides information on the analysis of the previous stage, so it is easy to understand and can be used as a reference for decision-making processes [11].

III. RESEARCH METHODS

This research is based on life cycle assessment method that consists of several stages i.e., defining inputs, process, and output as well as the environmental impact associated with manufacturing processes of Healthy Trolley. First stage is make the goal and scoping to identify resource use, energy consumption and waste release to environment. Then an inventory analysis is done to assess the human effort and ecological impacts of energy, raw materials that being used and environmental impact during product life cycle. Analytic hierarchy process is used to evaluate the results of the inventory analysis phase. Further a depth analysis of eco-profile of the product is done to develop alternative design improvement of healthy trolley product.

IV. RESULT AND DISCUSSION

4.1 Product Structure of Healthy Trolley

Healthy trolley product has the dimensions of 40 cm x 32 cm x 65 cm with three main parts as shown in Figure 1 i.e.,:

a. Body of Healthy Trolley
- Basket, made from hollow iron plates assembled with the frame made of iron using electric welding.
- Bulkhead, made from hollow iron sheet.
- Handle, made of cylinder steel with a diameter of 10 mm through the process of bending 90 °.

b. Legs Healthy Trolley
- Sub frame, cylinder iron assembled with four 5-inch diameter wheels.
- Buffer, made from cylinders steel and plates.

c. Drive System
- DC motors, the main components are made of cast steel to transform the electrical energy from dry batteries to mechanical energy to facilitate the flexibility in product height setting by customers.
- Clutch, made from iron rods to be connected with a DC motor.
- Dry battery, the main components are made of metal lead peroxide (PbO2), metallic lead (Pb), water (H2O) and sulfuric acid (SO4) that serves to store electrical energy that will be used by the DC motor.

Figure 1. Main Parts of Healthy Trolley

4.2 Production Process of Healthy Trolley

Based on product structure of healthy trolley product, the main raw material used consisted of plate and cylindrical iron. The raw material is processed by using some manual machine tools such as cutting machines, lathes, drill and pipe bending. Furthermore, all product components are assembled manually using electrical welding. The whole process takes 353 minutes for a healthy trolley product. Meanwhile, to ensure the product has a good quality, inspection process is required for 70 minutes. So the total time of the production process around 423 minutes / product.

4.3 Life Cycle Assessment of Healthy Trolley

a. Goal Definition and Scoping

This study has the objective to integrate environmental impact assessment on the product development phase. The object of this study is products prototype of healthy trolley that being developed in the Manufacturing Systems Laboratory. The scope of this study are materials procurement, production process, use and end use of the product.

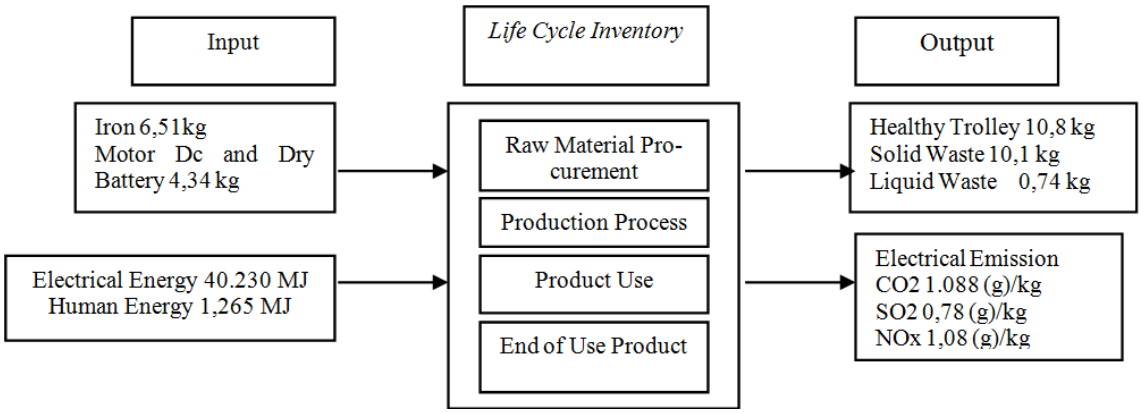

Figure 2. Energy Balance of Healthy Trolley

b. Product Life Cycle Inventory (Inventory Analysis)

In the stages of inventory carried out an analysis of the use of raw materials, energy, emissions and environmental impacts resulting from healthy trolley product. Then analysis on the energy balance is shown in Figure 2. Based on the energy balance of healthy trolley product, waste at the end of use is a factor that gives the greatest impact on the environment.

c. Product Life Cycle Impact Assessment

Product life cycle impact assessment carried out to raise the potential impact in the form of analysis. There are three stages of assessment i.e.,

- Classification

  Based on healthy trolley product life cycle starting from the procurement of raw material to end use product, this product produce emissions and waste that have implications for human life and the environment. Waste in the end use of the product gives the biggest negative impact on the environment and humans. Therefore, the impact that being analyzed is focused on solid and liquid waste in the end use of product.

- Characterization

  Waste produced by healthy trolley products can have a negative impact on living organisms and the environment, such as eco toxic aquatic, terrestrial eco toxic, acidification, human toxic. The impact of the emissions [1] produced by healthy trolley product shown in Table 1.

Table 1. Environmental Impact

Type of Waste	*Aquatic Eco Toxic (AE)*	*Terrestrial Eco Toxic (TE)*	*Acidification (AC)*	*Human Toxic (HT)*
Iron (Fe)	√	√	-	√
Timbale (Pb)	√	√	-	√
Sulfuric Acid (SO4)	√	√	√	√

Aquatic eco toxic is pollution caused by chemical substances that dissolve in water. The impact of this pollution is declining water quality. Terrestrial eco toxic is soil contamination that will remove the soil layer of containing nutrients. While acidification is acid rain as one of the effects of air pollution that can affect social and economic activities i.e., rain drop in acidic (pH below 7) to earth. Human toxic is a potential toxicity or carcinogenic in humans caused by a particular material.

- Valuation

Valuation for solid and liquid waste produced by healthy trolley product is done using qualitative assessment method. Value is then weighted using the analytic hierarchy process. Based on Figure 3, solid waste in the form of iron (Fe) in healthy trolley products give the biggest impact than other types of waste. This is because iron (Fe) is the main materials of this product. However, iron (Fe) can be recycled into other products. While lead (Pb) and sulfuric acid from the Healthy Trolley drive system although the levels are not too big, but these materials can not be recycled.

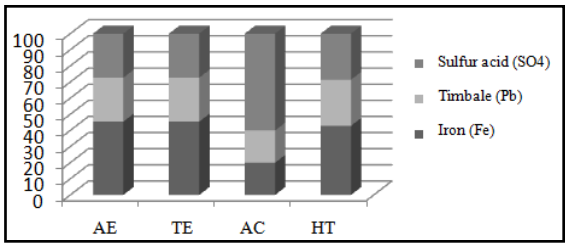

Figure 3. Environmental Impact Value of Healthy Trolley (%)

d. Evaluation and Improvement Analysis

The results of product life cycle inventory and product life cycle assessment then being analyzed as a basis consideration in generating alternative product design improvements. Some of the steps recommended in order to use the raw materials become more optimal and minimize the impact on

the environment are as follows:

- Need a drive system replacement components of healthy trolley with cylinder iron that assembled from handle and frame. This drive system does not work using dry batteries, dc motor and clutch like the previous design, but using a manual system. Users simply pull the handle up or down in accordance body dimensions manually. Healthy Trolley design alternatives can be seen in Figure 4.

Figure 4 The result of Healthy Trolley Design Improvement based LCA

- The need for waste treatment design of healthy trolley product that can be recycled such as chunks and flakes of iron (Fe).

V. CONCLUSION

Analysis of healthy trolley product sustainability using LCA method performed during the product life cycle starting from the procurement of raw materials, production processes, use and end of use product. The research shows that the largest environmental impact comes from the material used in product i.e., iron (Fe), lead (Pb) and sulfuric acid (SO4). So alternative healthy trolley product design improvements obtained is replacing the drive system into manual to eliminate the environmental impact derived from material waste of lead (Pb) and sulfuric acid (SO4).

VI. ACKNOWLEDGEMENTS

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