

# **Integrated eco-design and ergonomic innovation into product design and development**

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## **Abstract**

Green product design has many attention recently since it brings environmental issues such as recycling, and green environmental. Eco-design as defined in ISO 14062 (ISO/TR 14062, 2002) is a design approach aiming to reduce the environmental impacts of products and services throughout the whole lifecycle, while assuring similar or improved services to the end customer. In this work, we focus on product development that integrates green design and ergonomic aspects. The product is called 3 kg gas rack. The eco-design has been applied in development the product, by selecting recycled steel bar as the material. Ergonomic assesment by applying CATIA software in the pre-development stage brings crucial improvent in user's working performance. The finished product is stand firm and functioning properly. it is fulfill customer requirement of green design product.

## **Keywords**

Eco-design, product design, innovation, ergonomic, product development

## **1. Introduction**

In recent years, many researchers and industry practitioner pay attention on green product innovation. The growing awareness of environmental issues has made the design of eco-friendly products a critical task for modern businesses. Recycling, sustainable material, energy efficiency and green environment can be considered as the issues. Innovation

in green product could emerge from the customer need and perspective. Green product innovation has been recognized as one of the key factors to achieve growth, environmental sustainability, and a better quality of life. eco-design is an activity of designing and developing new products that pay attention to the impact of their use on the environment, both when the product is launched to the market, when the product is used or when the product's life ends.

In order to integrate the need of eco-efficiency with other company objectives, it is requires to support decision maker in the company with analysis tools offering guidance in the definition of specific actions. Such tools must provide valid support in all the main areas in which eco-efficiency strategies are developed and implemented, i.e. product design and innovation; design, innovation and improvement of technological manufacturing processes; and design and management of the production and logistics system. (Cagno and Trucco 2007)

For the company, its success in product innovation means that the company is one step ahead of its competitors. This requires the company's intelligence in recognizing the tastes of its customers so that the innovations it does in the end are in accordance with the wishes of its customers. Thus, product innovation must be planned and carried out carefully. Green design by using QFD application has recently increased attention as product design influences not only economic and technique requirements but also environmental issues such as recycling, energy efficiency, sustainable material, healthy environment. (Erginel and Kayapinar 2017)

Designing of the new product includes the process of changing the form, components, materials, and packaging of product. Product design is changing an innovation and technological development. green product innovation is a multi-faceted process wherein three key types of environmental focus – material, energy, and pollution – are highlighted based on their major impact on the environment at different stages of the product's physical life cycle – manufacturing process, product use, and disposal.

It is important to note that neither all products have a significant environmental footprint on each stage of physical product life cycle nor does the footprint stem from all aspects (material, energy, and pollution) but almost all products have significant environmental impact in at least one of the stages. Eco-design that applied in a product life-cycle perspective, is an effective way to solve environmental problems. (He, Luo, and Huang 2019) In this work, eco-design product is used as the term to determine the strategy that substitute material with the recycled one. The aim of this study is to determine the customer requirements of green product and tranform into daily product.

## **2. Literature Review**

Refer to (Ghisetti, Montesor, and Vezzani 2021), eco-design can be defined as a process of designing new products and production processes by considering their impact on the environment. In many literatures the term 'eco-design' is translate as green design. (Dangelico and Devashish 2010). Green product design is a conceptual approach which integrated environmental considerations into companies' design and product design.(Erginel and Kayapinar 2017) Eco-design as defined in ISO 14062 (ISO/TR 14062, 2002) is a design approach aiming to reduce the environmental impacts of products and services throughout the whole lifecycle, while assuring similar or improved services to the end customer. The idea is still to meet the consumer's requirements, but in a more sustainable way (Crul & Diehl, 2009).

Green design implicates evaluating the product life cycle from the raw material gaining stage to the recycling and disposal stages to foresee their impact on the environment, which includes an important information which design-related. (He et al. 2019) According to conceptual framework for green product innovation (Dangelico and Devashish 2010), there are three key environmental dimensions of green product innovation such as energy minimization, materials reduction, and pollution prevention as identified in the life cycle phases of products. eco-design improvements can be achieved effectively in the circumstances where adequate design information available. The life cycle modeling and assessment of product design were the key issues for the environmental. (Kong et al. 2022)

Beside green design, another factor could improve product function and performance is ergonomic design. According to (Tytyk and Mrugalska 2018), ergonomic design is the way of the design process which considered human-centric conditions. Ergonomic design principles are applied in order to improved handtool in carpet Industry. (Motamedzade, Choobineh, and Amin 2007).

Ergonomic innovation in design phase can be achieved through efficient ergonomic analysis tools called CATIA. By applying CATIA, the simulation of computer-aided designs enable analyze comprehensively all factors among the

man-machine interactive processes and can offer detailed solutions of ergonomic design for designers. (Ye, Li, and Li 2013) one of assesment method include in CATIA is RULA, stand for Rapid Upper Limb Assesment. Rapid Upper Limb Assessment (RULA) is a quick observation method of posture analysis. (Dockrell et al. 2012; Edith et al. 2020)

### 3. Methods

Qualitative and quantitative methods, both are applied in this study. The data were collected using voice of customer questionnaires. The objective of these questionnaires is gathering information of consumers needs in the innovation of 3 kg gas cylinder rack innovation, and data collection on the manufacturing process. The quantitative data were collected by conducting direct observation and measuring the object of study. The research stages is shown in Figure 1.

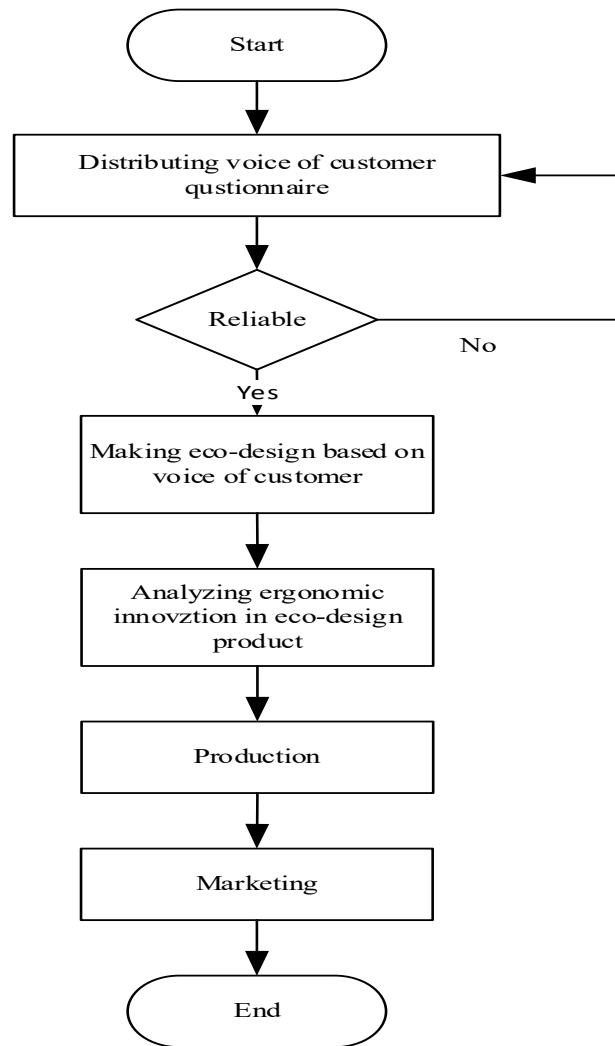


Figure 1. Research Flowchat

### 4. Data Collection

In this work, as much as 58 questionnaires were distributed into customer with various background in order to obtain the specific requirement of customer need. Ninety one percent of questionnaire is returning back, while the rest are missed. The information of voice of customer is recorded and is used in the next phase of product development. Direct

measurement of product dimension was conducted in-pre design stage. The result of measurement become important information to determine the size of product accurately.

## 5. Results and Discussion

### 5.1. Eco-Design Product.

The information gather from customer survey is transform into technical drawing in product design phase. (see Figure 2). This produk namely, 3 kgs Gas Rack, consist of 3 level of shelves. The first level is for storage gas tube, second level and third level are for keeping kitchen utensils. This design have advantages both environmentally and ergonomically.

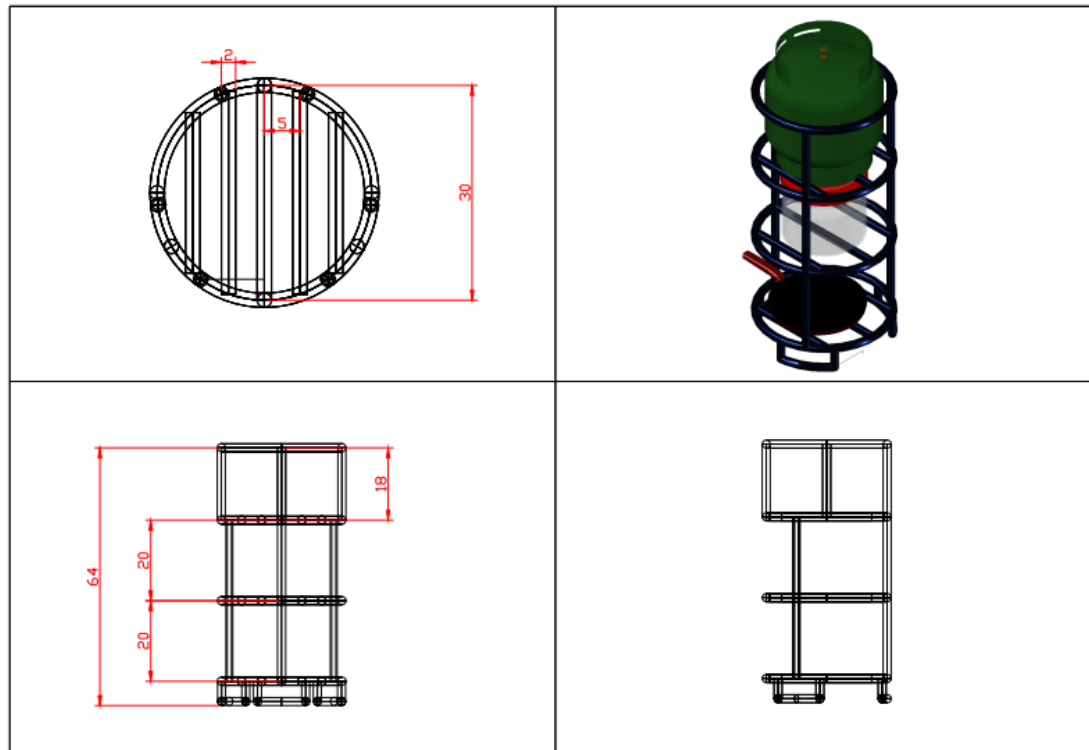


Figure 2. original design with different perspectives

The Figure 2 displays four perspectives of racks. This rack is design for storage 3 kg gas tube which common used by household in Indonesia. In the clockwise direction, design of final product, side view, front view and bottom view. The diameter base is refer to the size of the gas tube and the allowance for shifting activity. Table 1 and (Figure 3-4)

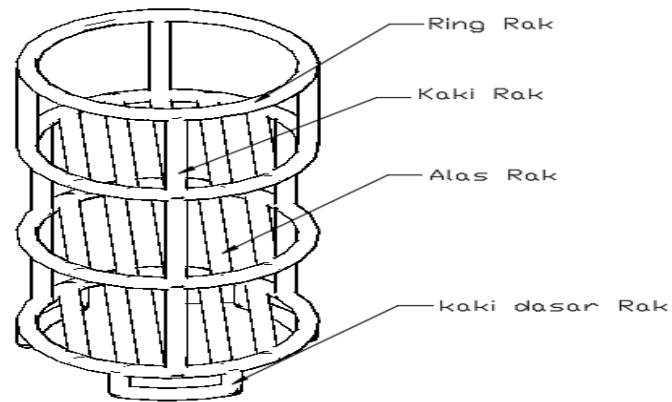


Figure 3. 3D perspectives of product

Table 1. Final product part dimension

Parts	Numbers of Parts	Size	Material
Rack Ring	4	95cm x 0,8cm x 0,8cm	Recycled steel bar 8mm
Bottom leg	3	58cm x 0,8cm x 0,8cm	Recycled steel bar 8mm
Base	9	29cm x 0,8cm x 0,8cm	Recycled steel bar 8mm
Shelf base	3	12cm x 0,8cm x 0,8cm	Recycled steel bar 8mm



Figure 4.(a) Production process and (b) Final Product

## 5.2 Ergonomic Analysis

In order to analyze how the eco-design product improve the user working performance, we simulate how user work with the object eith and without designed-product using CATIA software V5. (Figure 5)

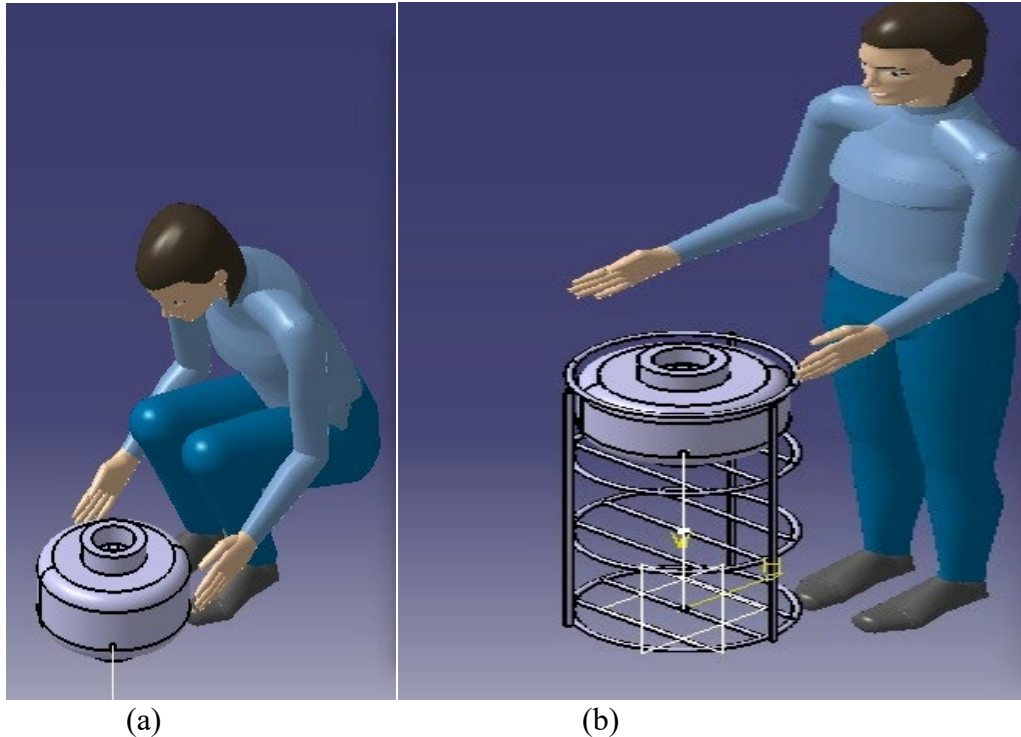


Figure 5. Ergonomic assesment by applying CATIA V5 (a) original working condition (b) after using product

The ergonomic assesment using Rapid Upper Limb Assesment (RULA) method which focus on posture analysis. The result indicates that RULA score for early condition is 6 and it is recommend that further investigation and changing in perform work are required. The innovation put in designed product show the reduction in RULA score. The final RULA score is 2. (Fig. 6b) Meaning that, the eco-design product proposed in this study could improve the user work performance.

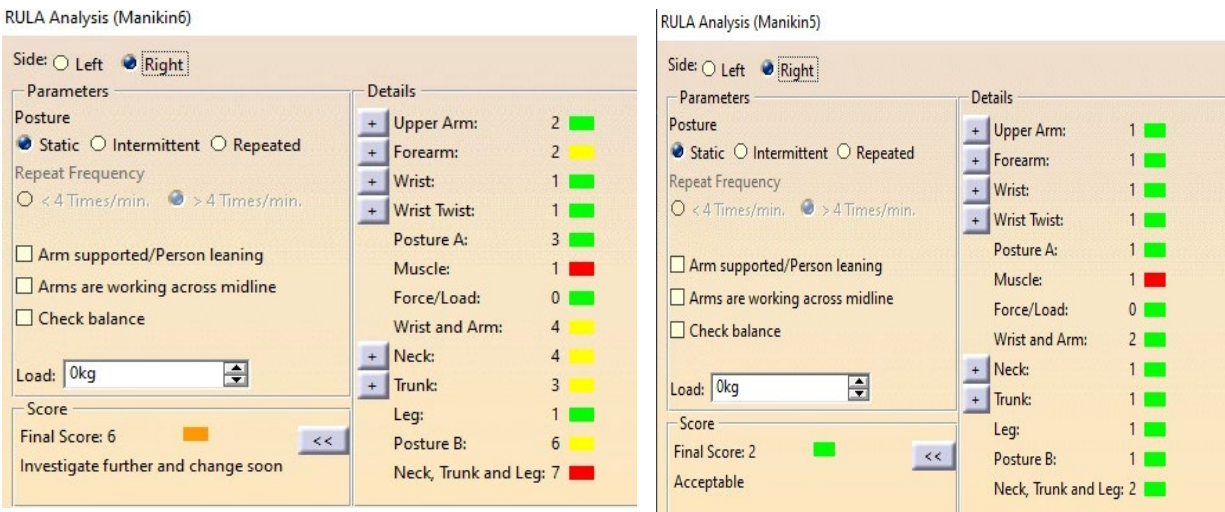


Figure 6. Ergonomic assesment using CATIA Software, (a) original working condition, (b) after improvement using innovation product

After final assesment, the rack is produced, and distributed in market place. (Figure 7)



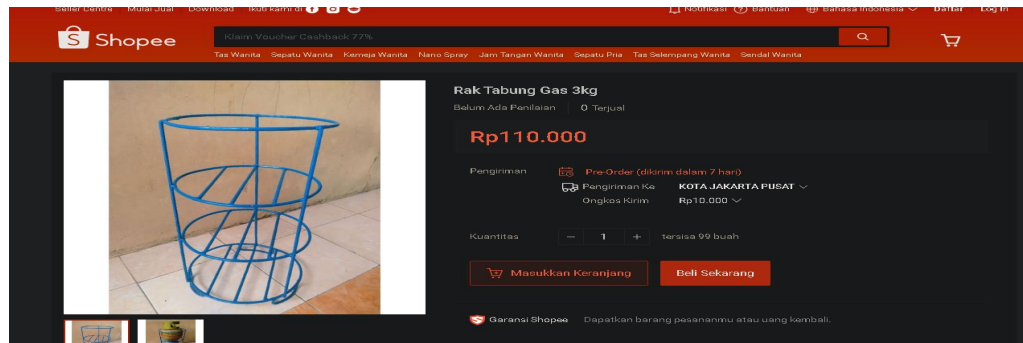


Figure 7. Product in market place

## 6. Conclusion

In this study, eco-design and ergonomic innovation has been successfully integrated into product design and development. The finished product has entered market place and fulfilled customer demand. Improving the technical and industrial innovation, a new breakthrough in a process or production techniques or novel products are preferred widely by consumers.

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## Biographies

**Yusraini Muharni** is senior lecturer at Department of Industrial Engineering, Faculty of Engineering, Universitas Sultan Ageng Tirtayasa, Banten, Indonesia. She obtained master degree in 2008 from Institut Teknologi Bandung (Industrial Engineering), and Bachelor (Industrial Engineering) from Universitas Sumatera Utara in Medan, Indonesia. She has been teaching at Universitas Sultan Ageng Tirtayasa specializing Production System courses for more than 20 years. Her research focus is production scheduling, warehouse layout, applied metaheuristic in production system and product design and development. Since 2018 she has been the head of Production System Laboratory in Universitas Sultan Ageng Tirtayasa. Now, She joined in Mechatronic and System Modelling Laboratory to enhance her research focus. She is active in writing academic articles for journal and conference in Industrial engineering area.

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