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PRODUCT DEVELOPMENT OF MOTORCYCLES EMERGENCY WHEELS EQUIPMENT USING THE DESIGN FOR ASSEMBLY (DFA) METHOD

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ABSTRACT

Motorcycles are a popular mode of transportation that people widely use to facilitate their daily activities. Behind the advantage, motorcycles also have disadvantages. As we often encounter or even experience ourselves, namely tire leaks. Riding a motorcycle with a punctured tire can exacerbate and endanger the user. Thus, the motorcycle must be pushed manually to the workshop for repairs which will undoubtedly require a lot of time and effort. Moreover, motorcycle users will feel tired and uncomfortable. From these issues, a solution was devised as a motorcycle emergency wheel tool. This tool's function is to support the leaking part of the motorcycle wheel and is inserted into the device that has been made so that the leaking tire is not damaged. The method used is designed for assembly (DFA). This method aims to study the processes and products of competitors in terms of design, quality, selection of materials, components, and production processes and then evaluate the assembly of manufactured products to design superior products. Based on the results of the development of a motorcycle emergency wheel tool that has been carried out, the innovative product is proven to have a lower price with a difference of Rp. 22,000 from the earliest product price. The assembly efficiency, earlier worth 0.9062 or 90.62%, can be reduced to 0.8169 or 81.69% by implementing innovative product designs.

Keywords: Motorcycles Emergency Wheels Equipment, Product Development, DFA

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1. INTRODUCTION

Motorcycles are a means of transportation used to facilitate daily activities. Motorcycles are the most popular mode of transport among the general public because of their advantages in terms of lower prices, the effectiveness of travel time, costs incurred for fuel, maintenance costs, and convenience of breaking through traffic jams. However, the use of motorcycles also has its drawbacks. As we often encounter or even experience ourselves, namely a leak in the tire. The most common cause of tire leaks is a sharp object piercing the tire rubber. Objects scattered on the highway and mainly invisible to the eye are the main enemy of tires. Riding a motorcycle with a punctured tire can exacerbate and endanger the rider. Therefore, the motorcycle must be pushed manually to the workshop for repairs. Pushing a motorcycle without using tools or machines will waste time and effort. Motorcycle users will also feel tired and uncomfortable. Therefore, the design of tools that can solve these problems needs to be done.

Design is any activity that creates and defines various solutions to problems that were not finished before, multiple solutions to existing problems, or answers to new issues that were previously only solved in different ways. One characteristic of the design activity is that it always begins at the end and ends at the beginning. This means that the focus of all design activities is the endpoint (product description) (Ginting, 2019). Product development is a series of actions that starts with analyzing market perceptions and opportunities, then ends with the production stage, sales, and delivery of products to consumers (Irawan, 2017).

The Design for Assembly (DFA) method determines product design with optimum time and cost (Firdaus, 2021). This method can be applied to product design to enhance quality and track advancements. DFA aims to simplify a product so that assembly costs can be reduced. In addition, the consequences of using DFA include increased product quality and reliability and reductions in production equipment and product components (Orshella, 2019). The basic concept of DFA or design for assembly is to analyze and solve manufacturing and component assembly problems in the early design phase so that the possibility of several aspects that impact the final product output can be anticipated as early as possible. That way, time can be saved, and production costs can be reduced.

From these problems, a solution was made by making emergency wheels equipment for motorcycles. This equipment supports the motorcycle wheel's leaking portion when inserted into the specially made device. If the leaking tire is allowed to continue to leak, it may harm both the motorcycle's wheels and the leaking tire. The method used in this research is Designed for Assembly (DFA). The purpose of this method is to study the processes and products of competitors in terms of design, quality, selection of materials, components, and production processes and then evaluate the assembly of manufactured products to design superior products. The emergency wheels equipment has existed before, but in the previous product, it was only used for small wheeled motors and was challenging to use for turning. In the development of this product, design and redevelopment were carried out so that all types of motorized vehicles could use this emergency wheels equipment without relying on the motorcycle wheel size.

2. METHODS

The method used in this study is Design for Assembly (DFA), which will result in ease in the component assembly process, minimize the components used, and simplify and shorten the assembly process (Ulrich and Eppinger, 2015).

The steps used in the application of the DFA principle during the design process are as follows:

1. The description of the earliest product design drawing.
2. Analysis of the earliest product Design for Assembly (DFA) table.
3. Calculation of the efficiency of the earliest product assembly using the formula :

$$E = \frac{T_a \times NM}{TM} \quad (1)$$

Description :

E = Design Efficiency (DFA index)

T_a = The theoretical minimum number of parts

NM = Basic assembly time of each part (average taken 3 seconds)

TM = Total assembly time of all parts

4. Material selection by estimating manufacturing costs and reducing component and assembly costs.
5. Elaboration of innovative product design drawings.
6. Creating The Operation Process Chart (OPC).
7. Completing and analyzing the DFA table of innovative products.
8. Calculation of the efficiency of assembling innovative products (Using Formula 1).
9. Comparison of earliest product and innovative product.

3. FINDINGS AND DISCUSSION

Data collection for research was collected in Betoyoguci Village, Manyar District, Gresik Regency. This research was held in December 2021 until the data was sufficient. The data needed are assembly time, number of innovative product components, component prices

3.1. The Earliest Product Description

The motorcycle wheels equipment shown in the image below has been selling for Rp294.000,00 in the market. Emergency wheels equipment for motorcycles has specifications for raw materials, namely aluminum plates, roller skate wheels, nuts and bolts, rings, and iron pipes. The size specifications of the product, are as follows:

Length = 35 cm
Height = 9.5 cm
Width = 16.5 cm

Figure 1. Earliest Product

3.2. Analysis of the Design for Assembly (DFA) Table of Earliest Product

Table 1. The DFA of Earliest Components Installation

No	Assembling Activities of Each Component	Theoretical Amount (NM)	Time (Minute)
1.	Installation of nuts with roller skates on the right side	2	4,12
2.	Mounting the ring on the right side of the wheel	2	1,45
3.	Installation of a bent iron plate as a front support	1	7,30
4.	Installation of a metal plate which is bent as a rear support	1	7,27
5.	Installation of the iron plate as the frame of the right body	2	13,45
6.	Installation of the front	1	3,21
7.	Installation of the rear iron pipe	1	1,04
8.	Installation of an iron plate as a frame on the front wheel	2	8,53
9.	Installation of a ring on the front wheel frame	1	1,08
10.	Installation of the front skate wheel	1	3,21
11.	Installation of nuts and bolts with the shoe wheel wheels on the front wheel frame	1	4,39
12.	Installation of the iron plate as the left body frame	2	7,44
13.	Installation of the ring on the left side	2	1,11
14.	Installation of roller skates on the left side	2	3,27
15.	Mounting the bolt with the left nut	2	5,32
16.	Installation of the iron plate as the base	1	8,56
	Total (TM)	**24**	**79,45**

Table 1 shows the total number of parts in the process installation of all components is 16, with 24 processes. The table also shows that the total measurement and assembly of all parts are 16 components, and the whole assembly time in making motorcycles emergency wheel tools is 4785 seconds or 79.45 minutes.

3.3. The Efficiency of Earliest Product Assembly

To determine the extent to which the efficiency of product assembly, the following formula can be used:

$$E = \frac{3 \times NM}{TM}$$

$$E = \frac{3 \times 24}{79,45}$$

$$E = 0,9062$$

From the calculation of assembly efficiency, the earliest product design has an assembly efficiency of 0.9062 or 90.62%.

3.4 Determination of Equipment Components and Materials

Table 2. Materials and Components of The Product

No	Materials and Components	Unit	Specification	Status
1.	Trolley Wheels	4	4 inch, L : 8 cm, W : 6 cm, H : 12,5 cm.	New
2.	Angle Iron	1	P : 1,5 m, W : 5 cm	Used
3.	Iron Pipe	1	T :1,7 cm L : 20 cm	Used
4.	Strap and Gesper	1	L : 2 m	New
5.	Iron Bar	1	L : 20 cm T : 1,1 cm	Used

Note :
L = Length
H = Height
W = Width
T = Thickness

Table 2 above shows the materials and the quantity of supporting components needed to assemble the innovative design product There are Five components, namely the trolley wheel material, totaling Four units with specifications of 4 inch, L = 8 cm, W = 6 cm, H = 12,5 cm. Four units of angle iron with specification : P = 1.5 m, L = 5 cm. An iron pipe material with a specification : thickness = 1.7 cm, P = 20 cm. A Gasper strap material with a specification : P = 2 m. An iron bar material with specification P = 20 cm, thickness = 1.1 cm.

Table 3. Production Cost of Innovation Product

No	Materials and Tool Components	Cost
1.	Trolley Wheels	Rp101.000
2.	Angle Iron	Rp 75.000
3.	Iron Pipe	Rp 5.000
4.	Strap and Gesper	Rp 14.000
5.	Iron Bar	Rp 7.000
Total		**Rp202.000**
	Labor Cost	Rp 50.000
	Overhead, etc	Rp 20.000
Total Biaya Keseluruhan		**Rp272.000**

Table 3 shows the price of making motorcycles emergency wheel tool. The tool has several materials and components: trolley wheels, angle iron, iron pipe, gasper strap, and iron bar.

Based on the total cost of the components needed to make the product, the cost of wages, overhead and others. The final price obtained is Rp272.000.

3.5 The Innovation Product Description

In this innovative product, researchers developed an emergency wheel tool on a motorcycle that is more assembly efficient and can facilitate user operation. Different raw materials make this motorcycle's emergency wheel tool more robust and sturdy. The advantages of innovative products can be used for all types of wheels because they have a width that can be changed according to the user's wishes. The design and final product of emergency wheels equipment for motorcycles will be shown as follows:

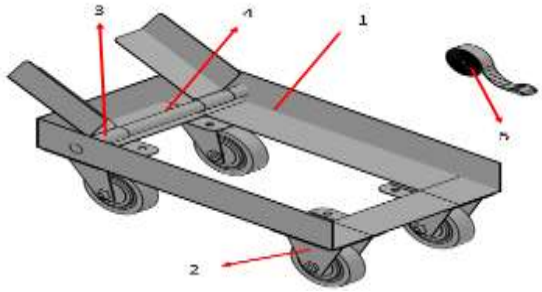

Figure 2. Innovation Product Design

The description of the constituent materials for each part :

1. Angle iron
2. Trolley wheels
3. Iron pipe
4. Gasper strap
5. Iron bar

Figure 3. The Final Product

3.6 Operation Process Chart (OPC)

The operation process chart (OPC) serves as a working map describing the process steps from the beginning to the finished product. The operation process chart (Figure 3) of the motorcycles emergency wheel equipment is explained as follows:

1. Measurement of angle iron for the body frame.
2. Measurement of the front support angle iron
3. Cutting the angle iron to the appropriate size.
4. Merging the angle iron into the body frame.
5. Measurement of the iron pipe as a hinge.
6. Cutting the iron pipe to the appropriate size.
7. Merging the hinges into the front supports.
8. Measurement of the length of the axle support.
9. Cutting the iron bar to the appropriate size.
10. Insert the iron bar into the supports.
11. Merging the front support to the iron frame.
12. Merging the trolley wheels.
13. Installation of gasper strap straps.

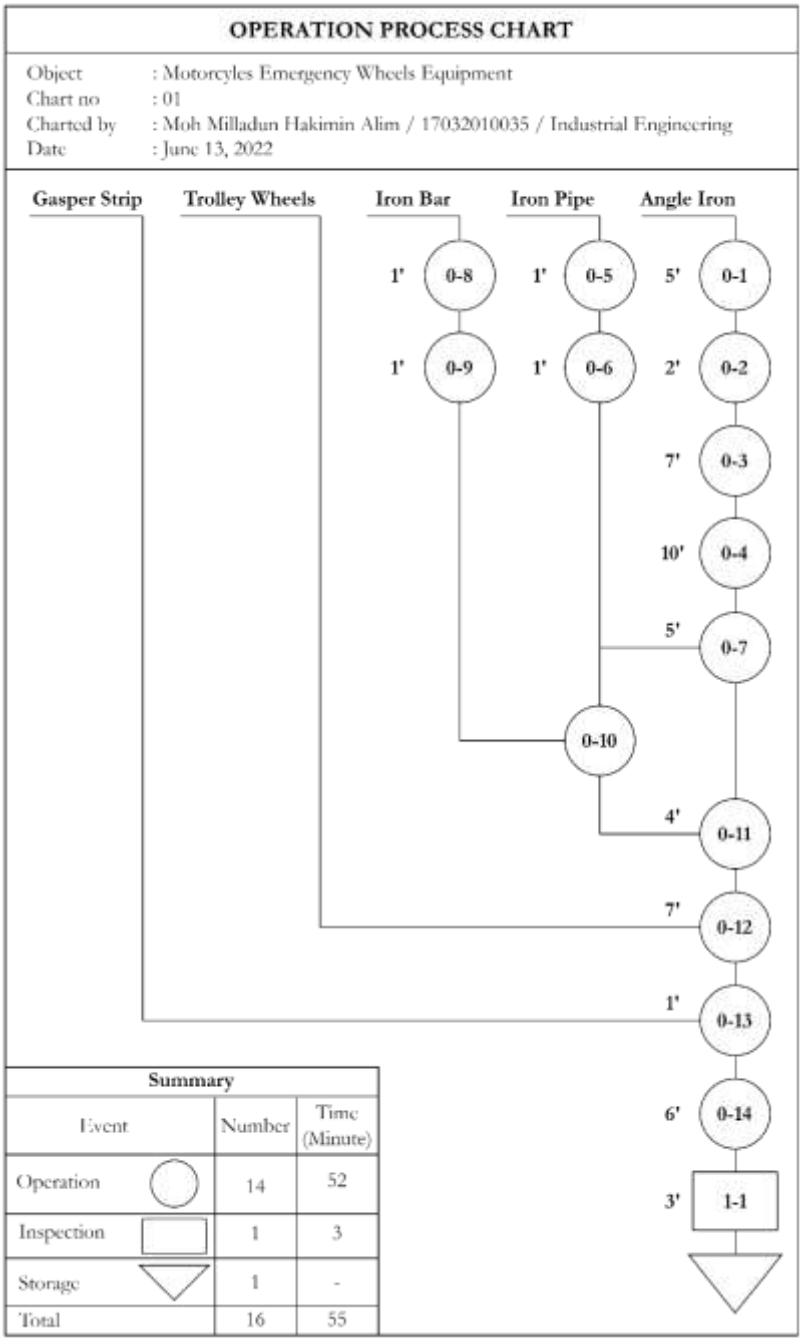

Figure 4. The OPC of Motorcycles Emergency Wheels Equipment

3.7 Analysis of the Design for Assembly (DFA) Table of Innovation Product

Table 4. The DFA of Final Components Installation

No	Measurement and Assembly for Each Component	Theoretical Amount (NM)	Time (Minute)
1.	Merging the angle iron into the body frame	4	22,15
2.	Merging the iron pipe and the angle iron as a front support	2	4,39
3.	Merging the iron pipe and the left-angle iron as a front support	2	5,02
4.	Insert the iron bar between the merge of iron pipe and angle iron	1	1,19
5.	Merging of iron bar with the body frame	1	7,34
6.	Installation of trolley wheels to the lower frame	4	12,47
7.	Installation of gasper strap to the frame	1	1,32
	Total (TM)	**15**	**55,08**

Table 4 shows the total number of parts in the process installation of all components is 7, with 15 processes. The table also shows that the total measurement and assembly of all parts are 7 components, and the whole assembly time in making motorcycles emergency wheel tools is 3308 seconds or 55,08 minutes.

3.8 The Efficiency of Innovation Product Assembly

To determine the extent to which the efficiency of product assembly, the following formula can be used:

$$E = \frac{3 \times NM}{TM}$$

$$E = \frac{3 \times 15}{55,08}$$

$$E = 0,8169$$

From the above calculations, it is known that the product design has an assembly efficiency of 0.8169. This means that the process of making product designs with a total of 15 parts and a total assembly time of about 55.08 minutes produces an assembly efficiency of 0.8169 or 81.69%.

3.9 Discussion

Table 5. Comparison of Earliest Product and Innovation Product

Assessment Aspects	Earliest Product		Innovation Product	
	Advantages	Disadvantages	Advantages	Disadvantages
Design	Attractive	_	Sturdy and strong	Unattractive
Size	Smaller	Unuseful for big wheel sizes	Adjustable for various wheel sizes	Bigger
Handle	Lightweight and bendable, so it is easy to carry anywhere and can be inserted into the motorcycle seat	_	Easy to carry by placing it in front of the motorcycle	Heavy, it can't be put in the seat and can't be carried under a sport-type motorcycle.
Utilization	Easy to use	Cannot turn freely	Easy to use	_
Safety	_	Impossible to use on bumpy roads and paved road	Possible to use on asphalt, cast, paved road	Impossible to past the speed bump on a paved road
Materials	Lightweight	Durability is not guaranteed and not strong enough to endure strain, pressure, or strenuous effort	Strong and durable	Heavy

The earliest product and innovative product each have advantages and disadvantages in several aspects. From the analysis above, innovative products have prominent advantages. The product can be used for various motorcycle wheels on asphalt, paving, and cast roads. In addition, innovative products also have benefits in terms of strength and safety in use. The weakness of an innovative product is it has a size that is too large, heavy, and cannot be inserted into the motorcycle seat, so the product can only be placed on the footrest of the motorcycle.

Developing an emergency wheels tool for motorcycles is done by making product designs easier to produce, more efficient production times, and selecting more substantial raw materials. Therefore, this innovative product focuses on security and safety because it involves the user's life.

4. CONCLUSION AND SUGGESTION

Based on the results of product development of emergency wheel tools for motorcycles, it was found:

1. The price is lower than the previous product, with the initial product having a price of Rp. 294,000. While the product innovation has a price of Rp. 272,000. The price of the earliest product with the innovative product shows a difference of Rp. 22,000 or 7.48% cheaper.
2. The total of parts in the installation of all components for the earliest product is 16 parts with a total of 24 processes, and the total assembly time is 79.45 minutes or 4784 seconds. Thus, the assembly efficiency for the earliest product design is 0.9062 or 90.62%. In comparison, the installation process of all components for innovation products is 7 parts, with 15 operations and a total assembly time of 55.08 minutes or 3308 seconds. Thus, the assembly efficiency for innovative product designs is 0.8169 or 81.69%.

Based on the results of the study, several things can be suggested:

1. For users of this innovative product. Using this product when the tire is punctured is highly recommended because it doesn't have to waste a lot of power to push the motorcycle.
2. For researchers. It is advisable to choose raw materials and component usage with more care. The product's design must be appropriate, and the calculations must be accurate.
3. For readers, especially the users of this product. This innovative product should be applied, both the dimensions and the innovations.

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