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Implementation design for assembly in two-wheel motorcycle chassis design (case study at hummeroad workshop)

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ABSTRACT

The use of two-wheeled motorcycles is quickly increasing in Indonesia. This is because two-wheeled motorcycles are a versatile, economical, and simple mode of transportation for daily purposes. Aside from being a mode of transportation, two-wheeled motorcycles are also utilised to transmit art through modification. The chassis of a two-wheeled motorcycle is one of the components that can be adjusted. The chassis is a frame composed of iron or steel that supports the vehicle's weight and load, including the engine and occupants. Chassis changes at the hummer road repair business are done on a made-to-order basis. As a result, before making chassis alterations, it is vital to identify the desired assembly design and estimate the expenses involved. This study attempts to: (1) learn about the implementation of Design for Assembly (DFA) on two-wheeled motorcycle chassis at the Hummerroad Workshop. (2) Determine the effect of the DFA approach on the assembly costs of two-wheeled motorcycle chassis at the Hummerroad Workshop; (3) Determine the effect of the DFA method on the design efficiency of two-wheeled motorcycle chassis at the Hummerroad Workshop. This study employs DFA to create a customised two-wheeled motorcycle chassis. The study's findings suggest that labour costs are reduced by IDR 200,000, materials are reduced by IDR 500,000, assembly time is reduced by up to 1.39 hours, and assembly efficiency is increased to 14% per item. This demonstrates that the DFA method can serve as an option for product design and development.

Keywords: Chassis; customization; design for assembly (DFA); two-wheel motorcycle.

1. INTRODUCTION

The use of two-wheeled motorcycles is quickly increasing in Indonesia. According to figures from the Central Statistics Agency (BPS), the number of two-wheelers in Indonesia increased by 48.9 million units, or 64%, between 2012 and 2022. At the end of 2022, Indonesia had 125.3 million motorcycles [1]. This is because two-wheeled motorcycles are a versatile, economical, and simple mode of transportation for daily purposes [2]. Aside from being a mode of transportation, two-wheeled motorcycles are also utilised to transmit art through modification [3]. The chassis of a two-wheeled motorcycle can be modified.

The chassis is an iron or steel frame that supports the vehicle's weight, engine, and passengers [4]. The chassis on two-wheeled motorcycles follows manufacturing specifications that are customized to the design of each plant. However, the chassis design is viewed as monotonous and dull, prompting people to modify it in repair shops. Chassis alterations in the repair shop can be customised to the desired design and budget [5]. Redesigning a product is one possible enhancement that can be used to a variety of situations [6].

The principles of product development always pertain to three areas of product quality: technical aspects (functions and requirements), costs, and production time. The technical aspect examines material strength, safety features, functionality, and comfort. Meanwhile, the cost and manufacturing time aspects are inextricably linked to the economic factors. Where these two features are truly dependent on the production and assembly processes [7]. Therefore, before carrying out chassis modifications, it is vital to identify the ideal assembly design and evaluate the expenses involved [8].

A variety of assembling methods have been developed. The design for the assembly (DFA) method is one that is thought to be useful and cost-effective for assembling two-wheeled motorcycle chassis [9]. This strategy tries to streamline the assembling process, reducing assembly costs and time. This strategy can assist producers in producing competitive items while maintaining the product's technical and functional qualities. In other words, the DFA approach can lower assembly costs while maintaining product quality, boosting product competitiveness [10]. The efficiency of pick-up automobile body assembly design is improved when the DFA method is used in study [11]. Although the DFA method is considered applicable and economical, there are not many repair shops that use this method for assembling two-wheeled motorcycle chassis. The purpose of the study is to determine the implementation of DFA on two-wheeled motorcycle chassis carried out at Hummerroad Workshop, to determine the effect of DFA method on the assembly cost of two-wheeled motorcycle chassis at Hummerroad Workshop, and to determine the effect of DFA method on the design efficiency of two-wheeled motorcycle chassis at Hummerroad Workshop.

Previous research identified no studies that applied the DFA approach to two-wheeled motorcycle chassis products, particularly caferacer models. Researchers used the findings of multiple research on various goods to raise the efficiency value, which served as the foundation for applying the DFA approach to two-wheeled motorcycle chassis products. In previous research with different products, the application of the DFA method to pick-up car body products showed an increase in efficiency value of 2.57%, namely from 20.52% in the assembly design efficiency of the old car design to 23.09% in the assembly efficiency of new car designs. Previous studies on vaccine carrier products found a 6% increase in assembly efficiency, from 18% to 24% for the improved design. This is supported by previous study on modified CNC router goods, which shows a 7.1% improvement in efficiency value, namely from 12.2% for the assembly efficiency of the first design to 19.3% for the new design.

2. METHOD

This study takes a quantitative method. The investigation was carried out for three months, from February to April 2023, at the Hummerroud workshop in Tanggulangin, Sidoarjo invited the caferacer motorcycle community of 50 members to submit feedback on the customised chassis. This workshop concentrates on the creation of two-wheeled motorcycle chassis products. However, the chassis employed in this study was a 225 cc Yamaha Scorpio caferacer motorcycle.

The research was carried out using field observations and literature studies. Literature review involves gathering journals, books, and other sources connected to the design for assembly process, as well as examining the findings of each existing study with various goods. Field studies involve setting research objectives and selecting research locations. After that, collect data on the assembly time of the original factory model chassis and customized chassis, labour expenses, material costs, and customer satisfaction with the results of the customisation. Based on the data collected, the DFA approach is appropriate for this study. Similar strategies for optimising product design include design for dependability (focusing on increasing product reliability), design for maintainability (focusing on ease of product maintenance and repair), and design for safety (focusing on safe product use). However, these three methods are judged ineffective since they do not consider the efficiency of product design work, including both the duration and cost of work. DFA analysis was conducted. The DFA analysis yields the overall chassis costs from the factory as well as the results of customisation, after which the acceptability of the chassis product is determined using a questionnaire to assess product quality, customer service, and chassis price.

The method used in this research is the DFA method. The use of this method aims to design two-wheeled motorcycle chassis products that are in accordance with consumer demand and minimised chassis production costs. In addition, it also aims to obtain alternative chassis assembly variables,

starting from the constituent components, estimating the overall cost, estimating the assembly time, and the efficiency of the two-wheeled motorbike chassis assembly. Data were analysed using the SPSS application with a paired t-test to figure out any differences before and after change. Those who are willing to provide feedback on chassis customisation in terms of product quality, customer service, and chassis price are qualified to join the caferacer motorcycle community.

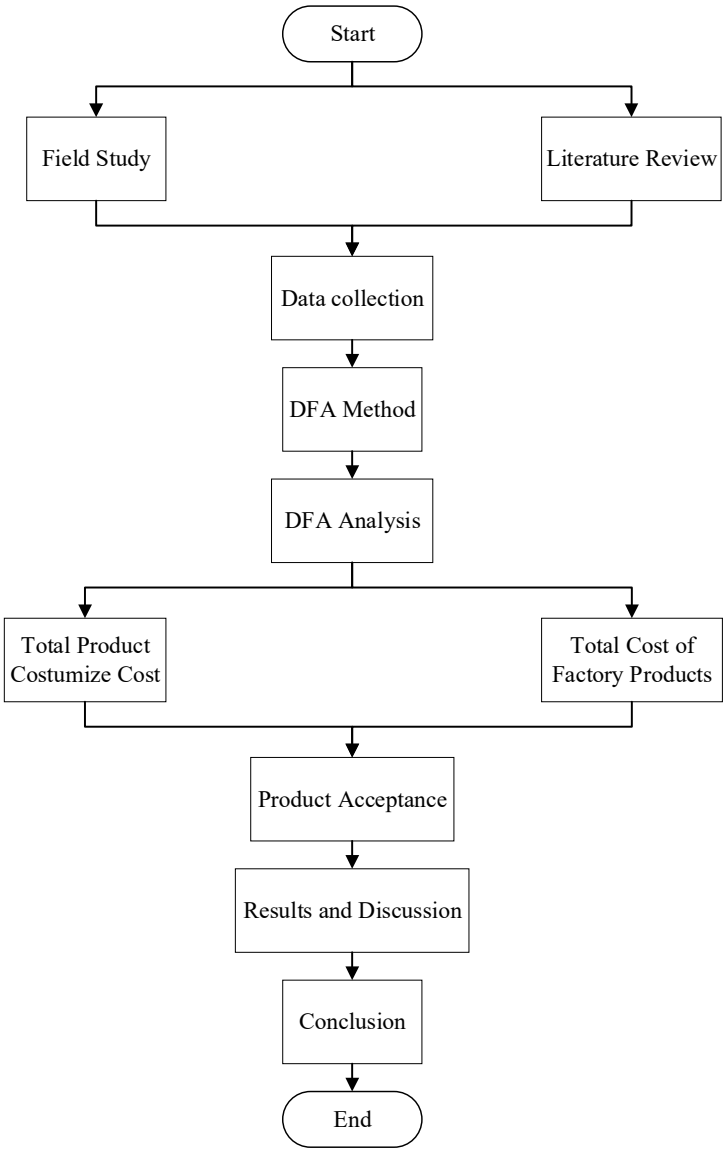

Figure 1. Flow of research implementation.

3. RESULT AND DISCUSSION

Data collection

Data was gathered through field investigations at Hummerroad workshops. The data gathered includes factory two-wheeled motorcycle chassis designs, the amount of components utilised, materials and material costs, assembly time, and product assembly error rates. Based on the data gathered, analysis was then carried out using the DFA method to get the efficiency level of two-wheeled motorcycle chassis assembly.

Customised two-wheeled motorcycle chassis design

The customised two-wheeled motorcycle chassis design must offer advantages over the factory chassis. Both advantages are in terms of a more appealing and efficient design, as well as function, which is stronger, sturdier, able to handle greater weight, and absorb shocks more effectively.

Figure 2. Two-wheeled motorcycle chassis design.

Figure 2 depicts a simpler and more ergonomic two-wheeled motorcycle chassis design, ensuring that riders are comfortable while riding. Aside from boosting aesthetic value, the chassis design above uses fewer and more efficient components, lowering the total cost of materials required.

Comparison of the price of custom and factory-built chassis

Based on the findings of field research at Hummerroad workshops, a comparison of labour costs and material costs for factory-made two-wheeled motorcycle chassis and bespoke two-wheeled motorcycle chassis can be shown in Table 1.

Table 1. A comparison of the price of custom and factory-built chassis.

Chassis Name	Chassis Type	Chassis Material	Number of Components	Assembly Time	Labor Costs (Rp)	%Error (Error Rate)	Ease of Assembly	Material Cost (Rp)
Factory	Double Cradle Frame	Steel	30	11	950.000	3	40	8.000.000
Custom	Double Cradle Frame	Steel	30	10	750.000	2	40	7.500.000

According to the data in Table 1, the labour expenses for assembling a factory-built two-wheeled motorcycle chassis are IDR 950,000. Meanwhile, the labour charges for assembling a custom two-wheeled motorcycle chassis are IDR 750,000. This demonstrates that employing the DFA approach to assemble a custom two-wheeled motorcycle saves IDR 200,000 in labour expenditures. Apart from that, the material costs for assembling a factory-built two-wheeled motorcycle chassis are IDR 8,000,000. Meanwhile, the material costs for assembling a custom two-wheeled motorcycle chassis are IDR 7,500,000. This demonstrates that building a custom two-wheeled motorcycle utilising the DFA approach can save IDR 500,000 in material expenses.

Customisation chassis assembly time

Aside from cost, another factor to consider is time efficiency when manufacturing the two-wheeled motorcycle chassis. Based on the findings of a field research at the Hummerroad workshop, a comparison of factory-built two-wheeled motorcycle chassis assembly times and customised two-wheeled motorcycle chassis can be shown in Table 2.

Table 2. Comparison of assembly time of factory built-in chassis and customized chassis.

Component	Amount	Factory chassis		Customized Chassis	
		Working Time Range per Component (Minutes)	**Total Working Time (Minutes)**	**Working Time Range per Component (Minutes)**	**Total Working Time (Minutes)**
Main Frame	1	120	120	90	90
Rear Frame	1	90	90	90	90
Front Fork Mount	1	45	45	40	40
Swing Arm	1	60	60	50	50
Engine Mounts	4	15	60	10	40
Footrest Mounts	2	20	40	25	50
Fuel Tank Mounts	3	10	30	10	30
Seat Mounts	2	15	30	15	30
Battery Holder	1	20	20	20	20
Electrical Wiring Mounts	5	10	50	10	50
Exhaust Mount	1	15	15	15	15
Radiator Mount	1	25	25	20	20
Subframe Connectors	2	20	40	20	40
Headlight Bracket	1	15	15	12	12
Handlebar Mount	1	20	20	10	10
Foot Pegs	2	15	30	10	20
Kickstand Mount	1	10	10	10	10
TOTAL	30	8,75 Hours	11,67 hours	7,62 Hours	10,28 Hours

According to the data in Table *2*, 17 components support the two-wheeled motorcycle chassis, for a total of 30 components. The factory-built two-wheeled motorcycle chassis components required a total assembly time of 11.67 hours. Meanwhile, the overall assembly time for the components that comprise the customised chassis is 10.28 hours. This demonstrates that employing the DFA approach to assemble a customised two-wheeled motorcycle can save up to 1.39 hours of time and reduce labour expenses.

Assembly efficiency

One of the most essential aspects of product design and development utilising the DFA approach is calculating the efficiency of a product's assembly design. Assembly design efficiency is calculated by comparing the theoretical minimum assembly time to the actual assembly time [12]. The effectiveness of assembly design is determined by a number of elements, including handling difficulty, component count, component dimensions, expected assembly time, and costs. To calculate the efficiency of building a product, use the following equation:

$$E_{ma} = N_{min} \times \frac{t_a}{t_{ma}} \quad (1)$$

Where:
Ema = DFA Index
Nmin = Number of minimal components by theoretical means
t_a = Basic assembly time of each component (±3 second)
t_{ma} = Overall component assembly time

The efficiency result are as follows:

$$E_{ma} = \frac{3 \times t_a}{t_{ma}} = \frac{3 \times 30}{10{,}28 \times 60} = \frac{90}{616} = 0{,}14 \quad (2)$$

Before changes were made, the factory-built two-wheeled motorcycle assembly design had an efficiency level of 0.1285, or 12.85%. The results showed that the customised two-wheeled motorcycle assembly design had an efficiency of 0.14, or 14%

Comparison of factory chassis design and customized chassis

A comparison of the design of the factory-built two-wheeled motorcycle chassis and the customised two-wheeled motorcycle chassis can be seen in Figure 3

Figure 3. Factory chassis (left) and custom chassis (right)

Based on Figure 3, we can see the difference in the design of the two two-wheeled motorcycle chassis. Customised two-wheeled motorcycle chassis (chassis models with new designs) have advantages in terms of a sturdier and stronger shape, efficient design, and attractive appearance compared to factory-built motorcycle chassis.

Discussion

When compared to factory-made two-wheeled motorbike chassis, the customised design in this study can save Rp. 200,000 and Rp. 500,000 in labour costs. The SPSS analysis revealed a significant difference in variance between the two groups, as indicated by the computed sig value (≤ 0). This demonstrates that the average cost of manufacturing a factory-built two-wheeled motorcycle chassis is higher than the cost of assembling a custom two-wheeled motorcycle chassis. The findings of this study are corroborated, who rebuilt the cake oven product, demonstrating that the DFA method can cut oven production costs by IDR 30,000. The whole initial price before using the DFA method was IDR 180,000, while the price of the oven after using the DFA method was IDR 150,000. Another study examined the redesign of food processor products. According to the research findings, the DFA approach can reduce production costs by up to 0.25 USD or 16.79 INR [13].

Aside from the cost, assembling a customized two-wheeled motorcycle chassis takes up to 1.39 hours less than installation of a factory-made two-wheeled motorcycle chassis. This is because a customised two-wheeled motorcycle has a simpler chassis design than a factory-made two-wheeled motorcycle. As a result, the efficiency of the custom two-wheeled motorcycle assembly design utilising the DFA approach is 14% higher than that of the factory-made two-wheeled motorcycle chassis assembly design. Results of a study on the assembly design of pick-up automobile body products. The findings of his study revealed that the assembly design efficiency increased by 2.57%, from 20.52% for the previous car design to 23.09% for the new car design.

The findings of this study are validated by other studies that apply the DFA approach on waste separation devices for ferromagnetic and non-ferromagnetic materials. His research found that the DFA approach can improve the assembly efficiency of the prototype machine for separating ferromagnetic and non-ferromagnetic material waste by up to 14.22% in principle and 11.83% in practice [14]. Other research strengthens the findings of this study. The design and development of vaccine carrier products using the DFA approach reveals that the overall assembly time for the first product design is 519.34 seconds, with an efficiency value of 18%. Meanwhile, the entire assembly time for the modified product

was 405.63 seconds, and the efficiency rate increased to 24% [15]. Other studies that redesigned CNC routers yielded similar findings. The design chosen for this study had an assembly time of 948 seconds or less, compared to the initial design, which had an assembly time of 1468 seconds. It employs 136 fewer components than the original design, which required 195, and has a greater engine efficiency of 19.3% over the first design's efficiency of only 12.2%. Another study found that the DFA method can improve the design efficiency of a cake oven by up to 19% relative to the original product [16].

4. CONCLUSION

The DFA approach can be used to help design and develop items for use on motorcycle chassis at the Hummerroad Workshop, where using the same amount of components can boost assembly efficiency and work time. Changing from a factory chassis design to a custom chassis design resulted in various cost benefits, including labour, material, and processing time savings. Labour costs are reduced by IDR 200,000, material costs are reduced by IDR 500,000, assembly time is reduced by up to 1.39 hours, and assembly efficiency is increased from 12.85% to 14%. This demonstrates that the DFA method can serve as an option for product design and development.

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