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Backrest Motorcycle Design for Passenger with Method of Quality Function Deployment, Product Design Specification, and Anthropometry Approach

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Abstract

The motorcycle is one of the favorite vehicles for the community, especially in Indonesia. Even the motorcycle has become a means of mass transportation to support the needs of its people. Its ability to pick up and reach locations to the corners of the city that cannot be done by other public transportation, the price is relatively cheap and faster to the destination, and passengers also do not need to jostle with other passengers. But the road conditions are jammed and activities all day long make them tired and feel they need a backrest on the motorcycle. Based on the results of the questionnaire given, they need a backrest tool on the motor. This backrest tool designed by researchers using the Quality Function Deployment method, Product Design Specification, and the anthropometric approach. The QFD method is to meet the needs and desires of consumers, the PDS method for tool design, and the anthropometry approach for tool convenience when used.

Keywords: *Anthropometry, Backrest Motorcycle, Quality Function Deployment, Product Design Specification.*

1. Introduction

In this fast-paced era, many people are starting to look for many ways to support their activities. Not only smartphones or laptops but also vehicles. One of the options for vehicles is a motorcycle. Some people prefer to travel by motorcycle than other vehicles such as cars because it is faster to arrive, more fuel-efficient, and cheaper. ASEAN Automotive Federation records data on the number of motorcycle sales in ASEAN, namely:

Table 1. ASEAN Automotive Federation Records Data

Country	2017	2016	Variance (%)
Indonesia	5,886,103	6,215,350	-5%
Malaysia	434,850	396,343	10%
Philippines	1,319,085	1,140,338	16%
Singapore	9,640	8,336	16%
Thailand	1,810,771	1,738,231	4%
TOTAL	9,460,449	949,598	-0,4%

Source: ASEAN Automotive Federation 2017

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Based on data in Table 1, shows that Indonesia has the most significant sales figures compared to other ASEAN countries, namely 6,215,350 units in 2016. Then the Indonesian National Police recorded the number of vehicles for each island in Indonesia on January 1, 2018:

Table 2. Number of vehicles for each island in Indonesia

No	Island	Personal Car	Bus	Box Car	Motorcycle	SUV	Total	%
1	Java	9,494,410	88,524	2,141,465	56,135,859	41,674	67,919,932	62.81
2	Sumatera	2,257,408	24,411	1,054,711	20,045,216	15,502	23,399,248	21.44
3	Kalimantan	472,065	7,732	324,097	5,568,617	2,677	6,375,188	5.72
4	Sulawesi	473,755	3,793	184,435	3,368,624	1,235	4,031,842	3.94
5	Bali	373,658	7,481	137,861	3,210,911	722	3,730,633	3.34
6	Nusa Tenggara	117,344	3,418	88,730	1,941,485	638	2,151,615	1.93
7	Papua	48,632	832	30,052	558,337	348	638,201	0.58
8	Maluku	15,870	184	9,526	238,483	176	264,239	0.24
	Total	13,253,142	136,375	3,970,877	91,085,532	64,972	108,510,898	100

Source: Republic of Indonesia Police January 1, 2018

From the data in Table 2, it is clear that the island of Java has the most significant figure of 62.81% compared to other islands, where major cities in Indonesia are located on the island of Java.

Now, in Indonesia, motorbikes have been used as a means of mass transportation, which is an online motorcycle taxi. The advantage of online motorcycle taxis can pick up and reach locations to the corners of the city that cannot be done by other public transportation. The price is relatively cheap and faster to the destination. Using transportation does not need to jostle with other passengers. But the road conditions are jammed and exhausted after a day of activity, which can cause discomfort in the neck or head, shoulders, upper back, arms and hands, lower back, and buttocks (Karmegam *et al.*, 2009). If having a backrest can reduce more moderate back discomfort (LBD) and overall body discomfort (OBD) (Máire Curran *et al.*, 2014).

Then the researchers distributed questionnaires to find out about the need for a backrest device on the motor. As many as 45 people became responsive to the survey.

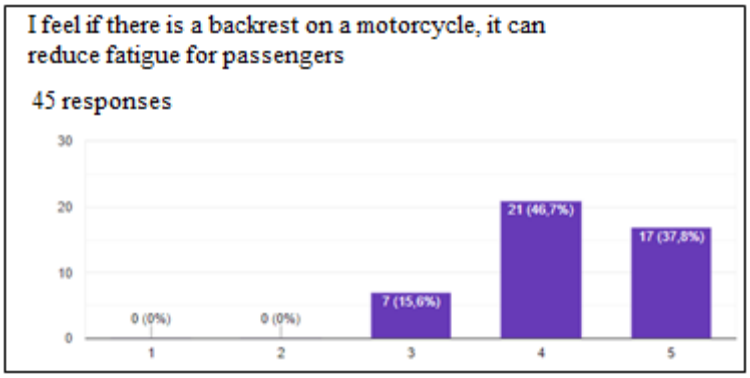

Figure 1. Safe and Comfortable Backrest Charts are required for Passengers When Tired

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From the results of the questionnaire, shown in Figure 1. There are 46.7% of respondents who answered agree that if there is a backrest on a motorcycle, it can reduce the fatigue of passengers. Based on the questionnaire, the researcher wants to design a tool that relies on passengers, which can help them take a short break on a motorcycle. Later this tool will be installed on one part of the motor, namely stirrup. The stirrup is a steel rod made of iron or rubber nylon, located on the back of the motorcycle.

2. Methods

2.1 Quality Function Deployment (QFD)

According to Widodo (2003), QFD is a way to translate consumer needs into products that will be developed later in which to meet the needs of these consumers, elements such as identification of consumer need to the planning of the production process will consider aspects of product quality and cost. Based on the above understanding, QFD is a method that makes it easy for us to translate consumer desires into the technical specifications needed for new products so that consumers can be satisfied.

According to Widodo (2003), the QFD stages consist of 4 main parts described in the House of Quality (HOQ), namely:

a) Product planning matrix that explains the relationship between customers' needs, technical requirements, co-relationships, contacts, competitive customer evaluations, competitive functional assessments, and targets.
b) Parts planning matrix, which is a matrix to identify critical part needs in product development.
c) Process planning matrix, a matrix used to identify critical process requirements in manufacturing products.
d) The production planning matrix is a matrix that identifies critical manufacturing requirements in running production.

2.2 Product Design Specification (PDS)

Product Design Specification, according to Rob Toulson and Tim Wilmshurst (2017), is the method used to design a tool before the process of making the tool. In creating the product, four steps are carried out, namely:

a) Job description. In the elaboration of tasks, the product specifications are arranged that have specific functions and characteristics that can meet the needs of the community. The goal is to gather information and describe it as clearly as possible and identify the constraints faced to achieve an optimal solution.
b) Concept design. At this stage, the translation of functions, function structure, and analysis of variants are carried out. At this stage, the plan has explained the system and concepts worked out from each component of the tool.
c) Tools image design, which provides a detailed tool image overall.
d) Detailed design.
   Detail design contains the design of the size for each component of the tool. This design can be used with specific methods or other approaches, which are following the designer's ideas and concepts.

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2.3 Anthropometry

Ergonomics has the principle of "fitting the task to the person," which means that in the design of an object, equipment, or work for a group or individual, everything needs to be considered for their needs and comfort. Information about the dimensions of the user's body is critical to know so that the tools are made easy to use and can provide support.

2.3.1 Definition of Anthropometry

Anthropometry is derived from the words Anthropos and metros. Anthropos means body and metros mean size. So anthropometry is a study that deals with measurements of the dimensions of the human body. According to (Wignjosoebroto, 2008), anthropometry is a study relating to the analysis of the aspects of the human body.

2.3.2 Anthropometry Percentile

Percentile shows a particular percentage value of people who have a size at or below that value (Wignjosoebroto, 2008). A population for study purposes is divided into one hundred percentage categories, where the benefits will be sorted from smallest to largest on specific body size. In statistics, the normal distribution can be formulated based on the average value and standard deviation of the existing data and combined with the actual percentile value.

2.4 Mechanical Mechanics

Mechanical mechanics is the study of and predicts the condition of stationary or moving objects due to the influence of forces that react to these objects. In mechanical mechanics, there is stress. According to Jatmiko (2011), stress is an internal force acting on an infinitely small area on a piece and consists of various quantities and directions. These inner forces are vectors in nature and survive in equilibrium with the external forces used (Popov, 1987). This voltage can be divided into two, namely normal stress and shear stress.

2.4.1 Normal Stress

Normal stress is the intensity of the force acting normally (perpendicular) to the slices experiencing stress and is symbolized by σ (sigma). Regular stress can be in the form of tensile stresses and compressive stresses. In tensile stress, if a pair of axial compressive forces push a rod, consequently this rod tends to shorten or compress the rod. Then the axial tensile strength produces compressive stress on the rod in an area that is located perpendicular or normal to the axis. In compressive stress, if a pair of axial compressive forces push a rod, consequently this rod tends to shorten or compress the rod. Then the axial tensile force produces compressive stress on the rod in an area that is located perpendicular or normal to the axis. At this compressive stress has the formula:

$$\sigma = P/A \tag{1}$$

Here: σ = tegangan (N/m^2)
P = axial frce (N)
A = cross sectional area (m^2)

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2.4.2 **Shear Stress**

Shear stress is the intensity of the force acting parallel to the plane of the surface area, denoted by τ (Tau).

A. Shear strain

Hooke's Law for shear states: $\tau = G\gamma$

$$\tau = G\gamma \rightarrow \gamma = \frac{\gamma}{G} \quad (2)$$

Here: G = shear elastic modulus
γ = unit shear strain, (radians)
τ = unit shear stress

B. Axial Load Deflection

An axially loaded axle length changes. Length changes that occur can be calculated by the formula:

$$E = \frac{\sigma}{\epsilon} = \frac{P/A}{\Delta/L} = \frac{PL}{A\Delta} \rightarrow \Delta = \frac{PL}{AE} \quad (3)$$

Here: E = modulus of elasticity (N/m^2)
ε = strain
L = stem length (m)
Δ = long change (m)

3. Result and Discussion

3.1 Questionnaire Distribution

The initial stage in designing a product is distributing questionnaires to see the needs of consumers for the tool. The survey was allocated using the Lemeshow formula, which are:

$$n = \frac{z^2 * p * (1 - 0{,}5)}{d^2} \quad (4)$$

$$n = \frac{1{,}645^2 * 0{,}5 * (1 - 0{,}5)}{0{,}1^2}$$

$$n = 67{,}65 = 68 \text{ respondent}$$

Based on the Lemeshow formula calculation, it is found that there are at least 68 respondents.

3.2 House of Quality

The first stage in applying the QFD methodology is to create a House of Quality (HOQ). This matrix serves to convert the voice of customer directly to the technical characteristics or technical specifications of a product (goods or services) produced. Researchers try to achieve technical aspects following the targets set, by previously benchmarking competing products. Below is the result of making HOQ.

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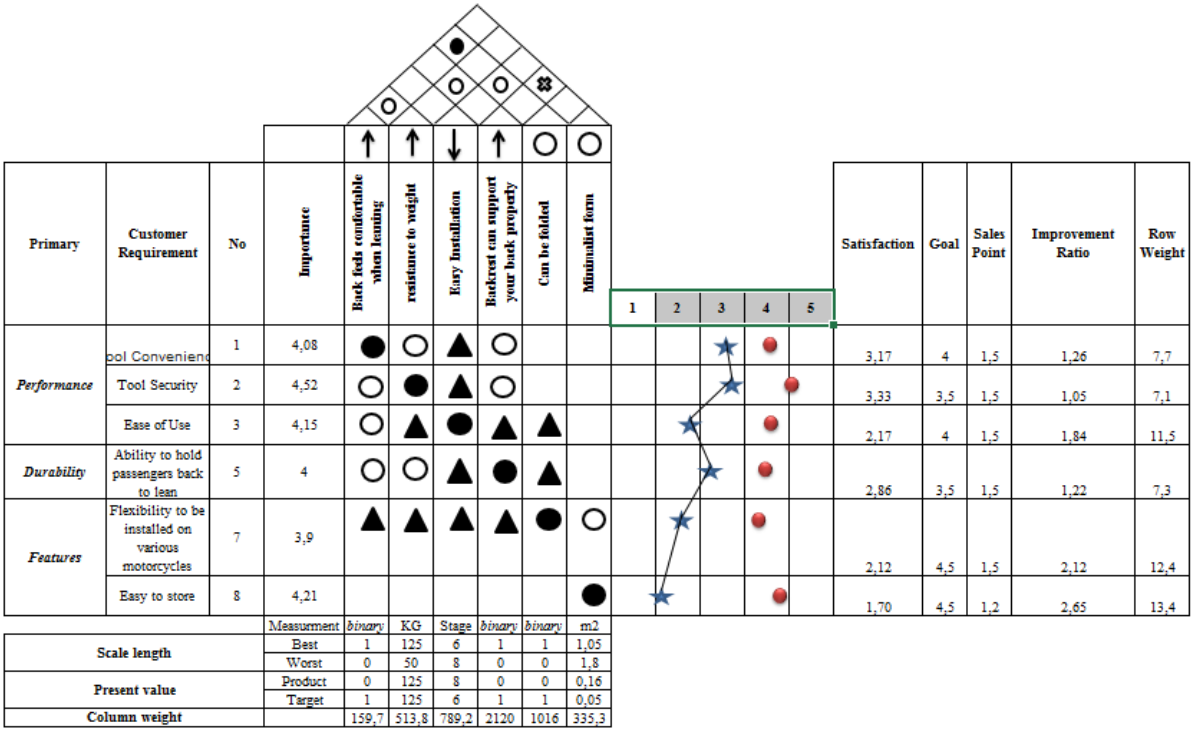
Figure 2. House of Quality



Primary	Customer Requirement	No	Importance	Back feels comfortable when leaning	resistance to weight	Easy Installation	Backrest can support your back properly	Can be folded	Minimalist form	Satisfaction	Goal	Sales Point	Improvement Ratio	Row Weight
				↑	↑	↓	↑	○	○					
Performance	pol Convenienc	1	4,08	●	○	▲	○			3,17	4	1,5	1,26	7,7
	Tool Security	2	4,52	○	●	▲	○			3,33	3,5	1,5	1,05	7,1
	Ease of Use	3	4,15	○	▲	●	▲	▲		2,17	4	1,5	1,84	11,5
Durability	Ability to hold passengers back to lean	5	4	○	○	▲	●	▲		2,86	3,5	1,5	1,22	7,3
Features	Flexibility to be installed on various motorcycles	7	3,9	▲	▲	▲	▲	●	○	2,12	4,5	1,5	2,12	12,4
	Easy to store	8	4,21						●	1,70	4,5	1,2	2,65	13,4
				Measurment	*binary*	KG	Stage	*binary*	*binary*	m2				
Scale length				Best	1	125	6	1	1	1,05				
				Worst	0	50	8	0	0	1,8				
Present value				Product	0	125	8	0	0	0,16				
				Target	1	125	6	1	1	0,05				
Column weight					159,7	513,8	789,2	2120	1016	335,3				

Table 3. Comparison of scale length values with results

Scale Length				Result
Technical Needs	Unit	Best	Worst	
Back fells comfortable when leaning	binary	1	0	1
Resistance to weight	Kg	125	50	125
Easy installation	step	6	8	6
Backrest can support your back properly	binary	1	0	1
Can be folded	binary	1	0	1
Minimalist shape	m2	1.05	1.8	0.0486

Table 4. Comparison of current values with results

Current Value				Result
Technical Needs	Unit	Product	Target	
Back feels comfortable when leaning	binary	0	1	1
Resistance to weight	Kg	125	125	125
Easy installation	step	8	6	6
The backrest can support your back properly	binary	0	1	1
Can be folded	binary	0	1	1
Minimalist shape	m2	0.160425	0.05	0.0486

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From the comparison table shown in Table 3 dan Table 4, between the scale length value and the results and the comparison of the current value with the results, it is known that all costs reach the specified target. So it can be said that the design of this tool is following the needs and desires of consumers.

3.3 Design of tools using the Quality Function Deployment method

In designing the equipment, it is, of course, necessary to compare the tools or materials to be chosen so that the product produced is maximum and has ergonomic value. In principle solution table shown in Table 5. This solution explains the comparison of tools as an alternative to be selected in the manufacture of the product.

Table 5. Principle Solution

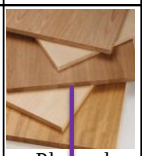
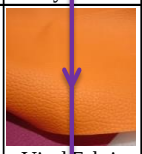
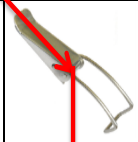
No	Sub Function	Solution Sub Function	A	B	C
1	Material	Frame	 Plywood	 Hollow Iron	 Stainless Iron
2		Foam Coatings	 Vinyl Fabric	 Oscar Fabric	 Woven Fabric
3	Lock	Lock Model	 Bicycle Clamp	 Bolt Clamp	 Clasps Clamp
4	Back Rest	Back Rest Type	 Vertical	 Curved	 Car Seats
5	Fold	Hinge	 *Custom*	 Lathe Door	 Butterfly Models

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Table 6. Determining the Best Alternative

The Best Alternative Selection Table	
Decision Criteria :	Decision :
(+) Yes	(+) Solution Sought
(-) No	(-) Delete Solution
(?) Less Information	(?) Gather Information
(!) Check Specifications	(!) See Specifications for Changes

Criteria	Fulfill the overall task								Decision
	Meet the will list								
	In principle can be realized								
	Time efficiency								
	Following the wishes of the designer								
	Care and safety								
	Allowable costs								
	A	B	C	D	E	F	G	Information	
Alternative 1	-	-	-	+	-	+	-	Does not fulfill the wish list	-
Alternative 2	+	+	+	+	+	+	+	Overall fit	+
Alternative 3	+	-	+	+	-	-	+	Dominant does not match criteria	-

From the results of Table 6, the best alternative determination table, it is known that the chosen alternative is number 2. When viewed from the principle table of the solution for the frame, the choice is iron hollo. This iron was selected because it is strong and durable; the price is relatively low compared to plywood and stainless steel. Then for the oscar fabric upholstery chosen because it has a thickness that is better than the vinyl fabric or woven fabric.

Although the price is higher, if it is durable, it is more economical. In the locking model, using models such as clip pins, but special modifications need to be made to fit the size of the iron on the motorcycle. The type of seat back that is used is like a car seat. This is because the backrest can be divided into 2, namely for the back and shoulder of the passenger. On the hinges using special modifications, because there are no tools on the market per the design you want to shape. From all these comparisons, alternative two was chosen, which also fit the specified criteria.

3.4 Shape Design Results

After selecting alternative two as a tool design reference, it can be seen the results of the design shape shown in Figure 3.

Figure 3. Shape Design

Figure 4. Picture Comparison

3.5 Anthropometry Design

This anthropometry calculation is used to measure tools according to the body dimensions of Indonesian people. The dimensions used are the width of the upper shoulder and the height of the seated shoulder with a 50% percentile. The results are shown in Table 7.

Table 7. Anthropometry Design

Body Dimensions	Percentile 50	Rounding 50
Upper Shoulder Width	34,28 cm	34 cm
Seated Shoulder Height	61,02 cm	61 cm

3.6 Mechanical Mechanics Calculations

The calculation of mechanical engineering here is to calculate the compressive stress and shear stress of the force applied to the tool

.

Table 8. Testing Comparison

Weight (Kg)	σ (Pa)	τ (Pa)	Comparison	Steel ST37 (Pa)
75	4546.487	1604.643	<	350000000
100	6061.983	2139.524	<	350000000
125	7577.479	2674.404	<	350000000

In Table 8 above, it is known that σ (Pa) is the compressive stress with Pascal units, while τ (Pa) is the shear stress with Pascal units. The table shows that the compressive stress and shear stress values are smaller than the strength of ST37 steel (hollow iron). This means that the steel can withstand loads up to 125 kg even more.

3.7 Budget for the Production Cost

The breakdown of the cost calculation of production costs for the manufacture of equipment.

Table 9. Budget for the Production Cost

No	Details	Price
Raw Materials		
1	Holo Iron	IDR 75,000
2	Plate	IDR 25,000
3	Foam	IDR 15,000
4	Oscar Cloth	IDR 25,000
Tool Design		
5	The Making of Motorcycle Backrest	IDR 150,000
6	Painting	IDR 50,000
7	Installation of Foam and Oscar Cloth	IDR 100,000
Total		IDR 440,000

Here a budget comparison is made for purchasing old products with the costs incurred to create tool development. This comparison can be seen based on the following table:

Table 11. Price Comparison

Old Product	Conclusion	New Product
IDR 200,000	<	IDR 440,000

From the price comparison table above, it is known that the cost of the old product is cheaper than the new product, in which the difference is IDR 220,000. The dispute occurred because there are different prices for the materials for the new product compared to the old one. The materials used for the new product are of good quality and better than the old product.

4. Conclusion

From the results of making the house of the quality matrix, it is known that various aspects to meet the needs and desires of consumers have been fulfilled. It can

be seen from tables 1 and 2, that all results are following the target to be achieved by researchers.

. In the selection of materials for manufacturing tools, there are three choices. The alternative chosen is alternative 2. The consideration in determining the option is because the raw material is relatively cheap and robust, the selected content is of high quality. Hence, it is durable, and the backrest shape is following the posture of the passenger, thus getting the best value in table 3.

This motorcycle backrest is measured based on the dimensions of the Indonesian body people, so it is expected that this tool can support the back of the passenger so as not to harm the user. But the resulting size is large enough so that if consumers want to put the tool in a bag, it won't be able to. This is one of the disadvantages of motorized backrest. With these shortcomings, it is expected to be a concern for further researchers.

This tool is declared safe to use because it has been through the calculation of pressure and shear pressure. This tool can withstand loads of up to 125 kg or more. This is because the tool material is made of hollo iron which is included in ST 37 steel with a capability of up to 350 MPa.

From the weight aspect, this tool has disadvantages if you want to be taken anywhere by hand, so it needs to be also considered in subsequent studies so that users are more comfortable to carry.

From the cost aspect, this tool is relatively more expensive than the previous product, because the manufacture of devices uses quality materials, so raw materials are also expensive. The process of making this tool is also quite complex, thereby increasing the cost of production.

In locking the motor iron, it will feel quite hard for women. This is due in securing the motor iron, it must be tight and firm so as not to be separated from the tool with the metal. This needs to be considered in subsequent studies to make it easier to lock in women.

References

[1] M.Curran, W. Dankaerts , P. O'Sullivan, L. O'Sullivan, and K.O'Sullivan, "The Effect of A Backrest and Seatpan Inclination On Sitting Discomfort and Trunk Muscle Activation", Ergonomics, **(2014)**.

[2] S.S.Jatmiko, “Analisa Kekuatan Deck Tongkang Muatan Tiang Pancang 750 DWT Dengan Software Berbasis Metode Elemen Hingga”, Fakultas Teknik Perkapalan., Universitas Diponogoro. Semarang, **(2011)**.

[3] K. Karmegam, M.Y. Ismail, S.M.Sapuan, N.Ismail, S.M.T. Bahri, S.Shuib, P.Seetha, "A Study On Motorcyclist's Riding Discomfort In Malaysia", **(2009)**, vol 4, pp (39-46).

[4] Popov, E.P, "Mechanics Of Material", 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs. New Jersey. USA, **(1978).**

[5] R.Toulson, T.Wilmshurst, "Fast and Effective Embedded Systems Design",2nd edition,**(2016)**.

[6] I.D.Widodo, Perencanaan dan Pengembangan Produk: Product Planning and Design. Yogyakarta: UII Yogyakarta Press,**(2003)**.

[7] S. Wignjosoebroto, “Ergonomi, Studi Gerak dan Waktu”, Jakarta : Guna Widya**, (2008).**