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Anthropometric chair design using the reverse engineering method to support practical learning

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ABSTRACT

Accurate measurements are essential to ensure tool alignment, machine precision, and measurement results. Currently, there is a difference in the height of students at the Astra Polytechnic, therefore an anthropometric chair is needed to facilitate the measurement of body dimensions. Anthropometric chairs are specialized tools for measuring body dimensions, but there are often some problems in their use. To overcome this problem, improvements are made through the Reverse Engineering method which aims to reproduce or recreate an existing model without using the original design documents. The main goal of this study is to improve the efficiency and accuracy of measuring students' body dimensions. These modified anthropometric chairs are expected to be easier to use, with an easily adjustable height and a simple disassembly and assembly process. The improved results show that the new design of the anthropometric chair is more efficient and improves the accuracy of measurement results, as well as providing more reliable data for a variety of purposes, such as product design and ergonomic studies.

Keywords: Anthropometric chair; practical; reverse engineering; manufacturing process design

1. INTRODUCTION

In the globalization industry in the manufacturing sector, measurement is very important in every element and process starting from tool alignment, machine precision level, and also the height of the workers [1]–[3]. Every human being also has a different height. With the difference in height in each person, an anthropometric chair is needed to make it easier to measure every dimension of the body. This is very much needed by the Manufacturing Process Design Laboratory. This laboratory has anthropometric-based learning [4]. An anthropometric chair is a tool that is specifically designed to measure the dimensions of the body. So that with the anthropometric chair, body measurements can be carried out optimally. In the current condition, the anthropometric chair has several problems where there are some parts that are not suitable [5], [6]. Various problems exist in the anthropometric chair such as problems with the chair, hydraulics, center pole, cylinder pole, arms, and pole clamps. From the existing problems, improvements need to be made to create an optimal anthropometric chair tool [7], [8]. Reverse Engineering or reverse engineering in a process in the manufacturing sector aims to reproduce or recreate existing models, components, subassemblies, or products without using existing design document data or working drawings [9]–[11]. Reverse Engineering is the act of dismantling an object to see how it works [12]–[14]. This is done primarily to analyze and gain knowledge about how something works but is often used to duplicate or refine objects [7], [15], [16].

Based on previous research [14], redesigning a jetski trailer using the reverse engineering method can improve the function of its features. The purpose of this study is to design an anthropometric chair as a tool that helps in measuring body dimensions optimally and efficiently. With the modified anthropometric chair, it is hoped that students can easily and accurately measure various dimensions of their bodies.

2. METHODS

This study uses a product development approach by implementing the CDIO (Conceive, Design, Implement, Operate) framework [17], [18]. Each stage in the CDIO framework has an important role in the process of designing and manufacturing anthropometric chairs. The following research stages can be seen in Figure 1.

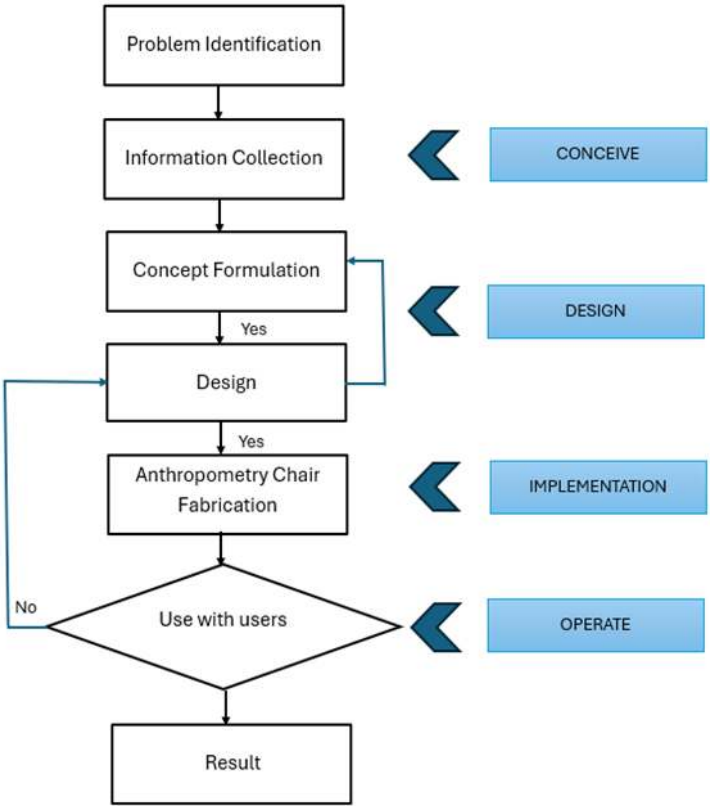


Figure 1. Research Stages with the CDIO Method

The CDIO method with the following steps [14]:

Conceive Stage: 1) Needs Identification: Through literature studies and direct observation of potential users, the need for an accurate, ergonomic, and easy-to-use anthropometric chair is identified. 2) Existing Product Analysis: A comparative analysis is conducted on anthropometric chairs that are already on the market to identify their advantages and disadvantages. 3) Determination of Design Objectives: Specific design objectives are formulated, namely to create an anthropometric chair that can provide accurate anthropometric measurements, support good posture, and be easy to use by various user groups.

Design Stage: 1) Concept: Several anthropometric chair design concepts are created by considering ergonomic, aesthetic, and functional aspects in Figure 2. 2) 3D modeling: The selected design concept is modeled in three dimensions using CAD (Computer-Aided Design) software for further visualization and analysis. 4) Ergonomic Analysis: An ergonomic analysis is conducted to ensure that the chair design is in accordance with the dimensions of the human body and supports good posture. 5) Material Selection: Materials are selected that meet the criteria of strength, weight, and aesthetics, and consider ease of production.

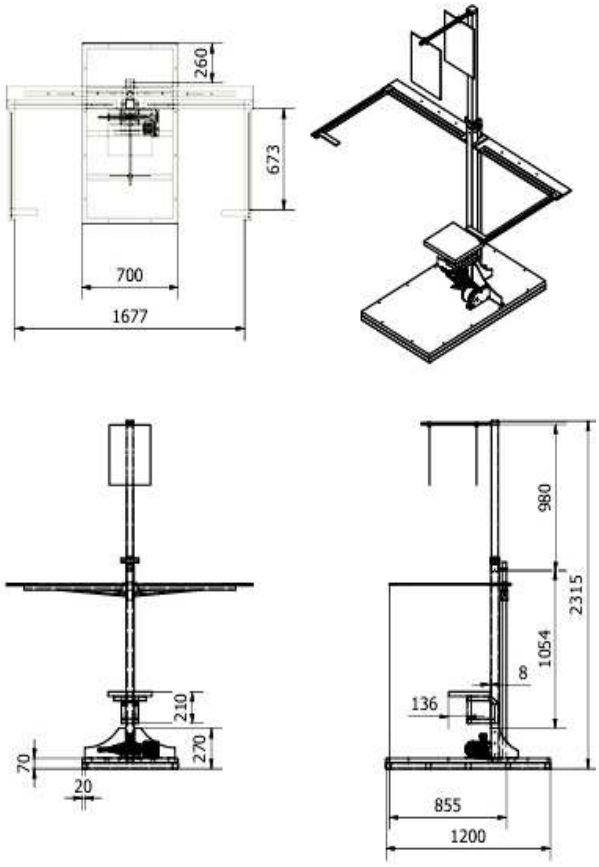
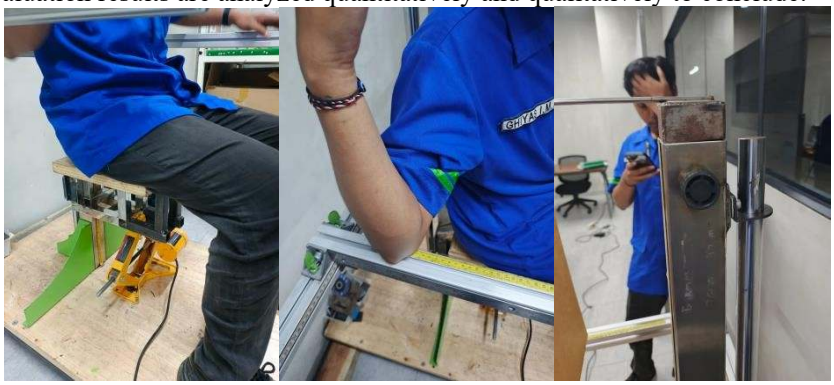


Figure 2. Anthropometry chair design

Implementation Stage: 1) Prototype Making: An anthropometric chair prototype is made based on the refined design. 2) Prototype Testing: Testing is carried out on the prototype to evaluate aspects of functionality, comfort, and measurement accuracy. Testing involves measuring body dimensions on several test subjects. 3) Design Revision: Based on the test results, design revisions are made if necessary to correct any deficiencies found.

Operate Stage: 1) User Evaluation: A user evaluation is carried out to obtain feedback on the comfort, ease of use, and practicality of the anthropometric chair. 2) Data Analysis: Data from user testing and evaluation results are analyzed quantitatively and qualitatively to conclude.



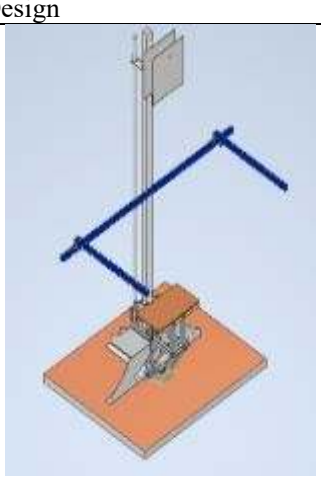
(a) Ease of Use (b) Ease of Use (c) Ease of disassembly

Figure 3. Usage evaluation

3. RESULT AND DISCUSSION

The Reserve Engineering anthropometry chair products. 1) Conceive: The Conceive stage is a crucial initial step in the process of improving anthropometric chairs. The stage begins with collecting evidence to reveal the problems that exist in the current chair. In other words, this stage is the process of collecting comprehensive data and information as a basis for making further improvements. 2) Design (designing) Design Requirements are Anthropometric chair products are lightweight and strong, the chair is easy to move, The arm measurement component should be strong, Comfortable sitting position, More effective measurement and easy use, and Easy maintenance. 3) Implement: Based on the agreed design requirements and manual anthropometric measurement data, then design by producing 2 concepts such as the designs in Table 1.

Table 1. Comparison of designs 1 & 2

Design 1		
Design	Aspect	Result
	Assembly system	Connection using full connection using welding
	Material	For the frame using Aluminium Profile 30 x 30 and 2 mm SPHC Plate
	Durability	Stronger in supporting large loads because it uses welded joints
	Cost	Relatively expensive because the use of welded joints requires a manufacturing process
	Maintenance	Maintenance is more difficult because it uses welded joints and requires more accuracy
	Operational	Rigid shape making it difficult to mobilize
Design 2		
Design	Aspect	Result
	Assembly system	Connection is not fully using welds but compared with nuts and bolts
	Material	The frame uses stainless material
	Durability	Compared to the full weld method, this method tends to have lower strength.
	Cost	In some cases, the initial cost of using bolts is lower than the welding method. The overall cost is higher, but it is more useful and durable because it uses a mixture so it is easier to improve
	Maintenance	Maintenance is easier because if there is a problem with the connection, the bolts can be easily removed and replaced without damaging the surrounding material.
	Operational	Easier to use because it is easy to dismantle and organise

Based on the results of designs 1 and 2, an analysis was then carried out to be reviewed and determined the selected design to be fabricated. The selection of the best design by considering several aspects with the results that can be seen in Table 2.

Table 2. Optimal Design Selection

No	Parameter	Design 1	Design 2
1	Assembly system	□	⊟
2	Material	⊟	⊟

No	Parameter	Design 1	Design 2
3	Durability	⊟	⊟
4	Cost	⊟	⊟
5	Maintenance	□	⊟
6	Durability	□	⊟

Based on Table 2, it can be seen that design 2 gets the highest score so fabrication is needed. This determination involves all design requirements needed for the anthropometric chair. The manufacture of anthropometric chairs carried out in one period starting in September-November from determining the theme to the Trial is shown in Table 3 Activity Plan as follows.

Table 3. Activity plan

Activity	Status	Sep	Oct				Nov
		4	1	2	3	4	1
Determine the theme	Plan	√					
	Actual	√					
Consultation	Plan	√					
	Actual	√					
Observation	Plan		√				
	Actual		√				
Design improvements	Plan		√	√	√	√	√
	Actual		√		√	√	√
Trial	Plan						√
	Actual						√

Operate: This process is carried out to select the direct problems that exist in the anthropometric chair in October 2024. The results of several problems Figure 3.

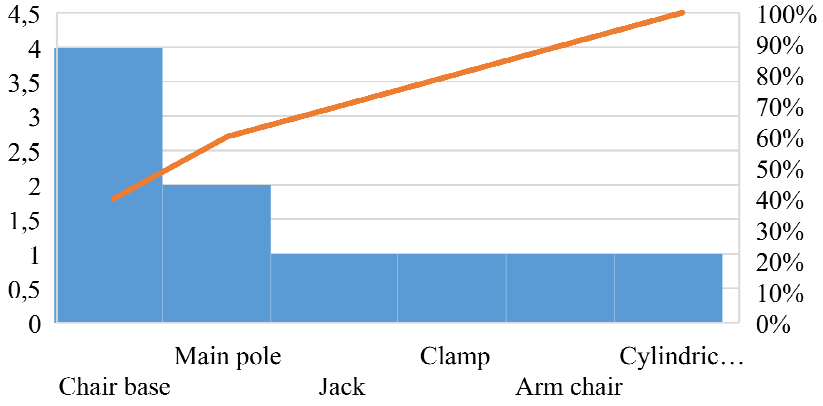


Figure 4. Pareto diagram

Based on several problems in the Pareto diagram, improvements were made with Problem Identification and Corrective Action (PICA) to improve the anthropometric chair. Problem improvement focused on problems in all parts of the anthropometric chair. The results of PICA can be seen in Table 4.

Table 4. PICA

Identification of problems	Improve
Chair	
The seat cannot be lowered when the jack is down.	Addition of connecting plate between jack and chair
The chair is difficult to disassemble and reassemble	Created a slot system

Identification of problems	Improve
Chair	
The seat cannot be raised to its maximum height.	The position of the pole is corrected
The position of the chair is not balanced	Change the position of the seat support about the jack
Main pole	
Leaning Pole	A square-shaped plate is made so that it can fit into a pole with the appropriate dimensions.
Main cylinder	
The pole is tilted because the position of the bottom plate is centered with the bolt hole.	The bottom plate is cut slightly to fit the position.
Jack	
Jack is not centered on the seat	Changing the position of the jack
Clamp	
The clamp holding the pole is not optimal and damages the carpet lining.	Clamp changes with bolts welded to the top of the clamp
Armchair	
The chair arms are not strong enough	Placement of clamps at the bottom to hold the chair arms.

Furthermore, based on PICA, a design evaluation was carried out and improvements were made as a problem-solving effort. With the new design, it is expected to improve the function of the anthropometric chair and as a comparison, it can be used easily and comfortably.

Discussion

The results of this improvement produce a better anthropometric chair design. The chair can now be adjusted in height easily and safely, making it suitable for various body postures. In addition, the disassembly and assembly process is simple. With a more efficient design, anthropometric measurements are more accurate and faster, providing more reliable data for various purposes, from product design to ergonomic studies.

4. CONCLUSION

Based on the previous analysis, it is known that the existing chair design that the anthropometric chair can be easily dismantled and reassembled is more efficient so that the results of measurements that were previously still manual with the anthropometric chair become easier procurement and improvisation of the anthropometric chair can help students in running the manufacturing production planning course, especially in module 6, namely anthropometry, and mobilization for chair maintenance becomes easier.

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