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Article

Ergonomically Based Garbage Transport Trolley Design Based on Anthropometric Data

Resy Kumala Sari^{1✉}, Raka Tabagus², Muhammad Nur³, Yi-Lang Chen⁴

Program Study of Industrial Engineering, Pahlawan Tuanku Tambusai University^(1,2)

Program Study of Industrial Engineering, Sultan Syarif Kasim Riau State Islamic University⁽³⁾

Department of Industrial Engineering, Ming Chi of University Technology⁽⁴⁾

E-mail: resy_kumalasari@universitaspahlawan.ac.id

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ABSTRACT

The current developments have made many companies vying to create or develop innovative and creative products, this greatly influences industrial development in Indonesia. Especially considering the increasing number of new Small and Medium Enterprises (UKM) industries in Indonesia which require companies to create a tool capable of coordinating production activities in these SMEs. The aims of this research are: 1. Able to design and build functional and ergonomic trolleys based on anthropometric data. 2. Able to demonstrate the efficiency of physical products from trolleys to material handling aspects. 3. To make products that can facilitate the transportation of waste to temporary waste disposal sites (TPS). Data collection was carried out by conducting interviews and measuring the body dimensions to 20 respondents consisting of 10 industrial engineering students class of 2018 and 10 random respondents aged 22-57 years. For the design of the trolley, there are 4 data variables that will be used, namely LB (44 cm), TPB (101.90 cm), JTD (63.10), PTT (16 cm) and several additional parts to make it more ergonomic and efficient. The conclusions of this study are 1. The design and manufacture of the trolley is in accordance with the anthropometric size of the human body where the trolley is very functional by providing a pulley on the trolley so as to facilitate the process of moving to the four temporary garbage disposals (TPS) and providing 3-axis wheels which function to facilitate the collection of waste through the stairs. Thus reducing complaints of diseases such as injuries to muscles, tendons, ligaments, nerves, cartilage, bones, or blood vessels in the hands, feet, neck, and back. 2. The physical product of the trolley is in accordance with anthropometric aspects and the trolley is also more efficient in its use.

1. BACKGROUND

1.1 Introduction

The current developments have made many companies vying to create or develop innovative and creative products, this greatly influences industrial development in Indonesia. Especially considering the increasing number of new Small and Medium Enterprises (SMEs) industries in Indonesia, which require companies to create a tool that is able to coordinate production activities in these SMEs. One of the most important production processes in SMEs is the transfer of materials or goods which is called material handling.

Material handling is one of the most frequently occurring processes in a production process company, starting from taking raw materials from the warehouse to transferring products to the finished product warehouse. A tool that can help in the material handling process is a trolley. According to [1] Trolley is a tool for moving goods from one place to another in the operational activities of a company or shopping place. Having a trolley can help save time and labor in the production process.

This Rresearch [2] discusses the design of a garbage collection trolley at the Batununggal Indah modern market. The purpose of this research is to increase the efficiency of the waste disposal process and how to design an efficient garbage collection device. The result of this research is the creation of a garbage collection trolley using a system that can increase time and energy efficiency for cleaners, this trolley has a locking system to lock the garbage can to be transported and a linkage system to lock the trolley when in use. In research [3] discussing the ergonomic design of a trolley as an aid in transporting gallons of water using the anthropometric method and the Rapid Entire Body Assessment (REBA) method, the purpose of this study was to analyze worker posture and overcome problems when lifting gallons over the stairs. Lifting gallons has an impact on reduced work productivity, causing pain to workers, both temporary and permanent, and increasing the possibility of an accident. The results of this study are the design of trolleys to provide comfort for workers with sizes according to the results of anthropometric data processing. While in research [4]. Using ergonomics and anthropometric aspects in providing proposals in the form of developing a garbage bin design based on ergonomics and anthropometric aspects. The concept of the trash can aims to find out and improve in terms of the width of the trash can which is adjusted to the optimal percentile data, then it is proposed to change the footrest on the automatic trash can by adjusting it to the data obtained so that it is comfortable to use. Thus, the author hopes that the design of the trash can facility has an ergonomic aspect based on anthropometric data from the human body. So that the designed trash can can be used practically, safely and comfortably.

The three studies stated above focus on designing ergonomic trolleys with reference to using anthropometric data with the aim of creating trolleys that are in accordance with the dimensions of the human body and ergonomic aspects, so as to create trolleys that are comfortable, comfortable, safe, healthy and efficient when used. As well as increasing productivity in workers so as to increase income for these workers. And from the design of the trolley aims to minimize the occurrence of injuries or accidents while doing work.

Anthropometry is a method used to measure the dimensions of the human body as a reference for manufacturing and product development. Apart from being a reference data in the manufacture of anthropometric products, it can also be used for designing work areas, designing work equipment, and designing physical work environments [5]. With anthropometric measurements, it can be seen what kind of product design is suitable for the market and also ergonomics. The manufacture of ergonomic products can minimize complaints of Musculoskeletal Disorders (MSDs). Musculoskeletal disorders are disorders characterized by injuries to muscles, tendons, ligaments, nerves, cartilage, bones or blood vessels in the hands, feet, neck and [6]. Using the results of data processing from the anthropometric method will produce products that are in accordance with the interests of the community.

This research will discuss about the design of the garbage collection trolley based on anthropometric ergonomics data to determine the specifications of consumer needs and desires. The front basket of the trolley will be replaced with a trash can that functions as a means of transporting garbage. With the design of this trash can transport trolley, it will provide a solution in disposing of waste for SME industry players. Based on the description of the problem against the background above, it can be formulated the problem in this research as follows:

1. How to design and build a functional and ergonomic trolley from anthropometric data.
2. How is the efficiency of the physical product from the trolley to the material handling aspect.

1.2 Research Purposes

The objectives of writing this research report are:

1. Able to show the efficiency of the physical product from the trolley towards the material handling aspect.
2. To create a product that can make it easier to transport waste to temporary waste disposal sites (TPS).

2. LITERATURE REVIEW

2.1 Design and Manufacture

Design is one of the most important things in making a product. According to Berto Nadeak, et al (2016: 54 in Rosidah, 2018) defines "Design is the first step in the engineering development phase of a product or system. Design is the process of applying various techniques and principles aimed at defining a piece of equipment, a process or a system in detail that allows physical realization. Meanwhile, according to Soetam Rizky (2011: 140 in Hatta, 2019) Design is a process of defining something that will be done using various techniques and it involves a description of the architecture as well as detailed components and limitations that will be experienced in the work process.

Manufacturing is a process of processing raw materials into semi-finished materials or ready-to-use finished materials. According to [3]. Manufacturing is the processing of raw materials into finished goods in physical form through a series of activities using company resources, these resources are human power, machines and other supporting equipment. Manufacturing is a series of interconnected operations and activities which include design, material selection, planning, manufacturing, quality assurance, and management and marketing of products. marketing of products) [3].

2.2 Material Handling

Material handling is the activity of moving from one location to another. According to the Material Handling Industry of America, material handling is defined as the movement, storage, protection and control of materials throughout the manufacturing and distribution process, including use and disposal. [4]. The main aim of material handling is to reduce production costs, besides that material handling has a big influence on the operations and design of the facilities implemented. The employment of advanced material handling techniques proves highly advantageous in elevating workers' burdens, mitigating the risk of lumbar discomfort, and averting injuries to muscles, nerves, tendons, bones, joints, cartilage, and various other physiological afflictions [5].

2.3 Trolley

At the beginning of its appearance, trolleys could only be found in supermarkets or supermarkets, this was because trolleys were initially created as a tool to help consumers when shopping, but as time progressed, many new trolley models emerged with various advantages. According to (Umma 2020) A trolley is a manual tool for moving goods that is very helpful, to make it easier to move goods on a large scale to the destination.



Figure 1. Shopping Trolley
Source: (Andhika 2017)

When the trolley appeared, it made it easier for humans to carry out movement activities. Some of the benefits of trolleys that can be found in everyday life include:

1. Easy to carry heavy items
2. Prevent injuries resulting from carrying heavy items.
3. Very practical and efficient

2.4 Ergonomics

Ergonomics is a "science" or multidisciplinary approach that aims to optimize human-work systems, so as to achieve tools, methods and work environments that are healthy, safe, comfortable and efficient. [8]. Meanwhile, according to (Pulat, 1992 in Susanti, Zadry, and Yuliandra 2015) Ergonomics is a scientific discipline related to the interaction between humans and the objects used. The birth of the branch of ergonomics was to increase the effectiveness of the use of physical objects and facilities used by humans and maintain or add certain values such as health, comfort and satisfaction in the process of use. The main goal of ergonomics is to design objects, equipment, and machines so that they can be used effectively by humans. In general, the objectives of implementing ergonomics include: Improving physical and mental well-being through efforts to prevent work-related injuries and illnesses, reducing physical and mental workload, seeking promotions and job satisfaction. [8]. Understanding the principles of ergonomics will make it easier to evaluate each task or job even though the science in ergonomics continues to progress and the technology used in the work continues to change.

2.5 Anthropometric Data

Anthropometry is the study of measuring the dimensions of the human body. According to Wignjosoebroto (2000 in Simanjuntak, Oesman, and Pramuditya 2020) Anthropometrics comes from "anthro" which means human and "metri" which means size. Meanwhile Tayyari and Smith (1997 in Wijaya et al. 2016) explained that anthropometry is

a study that is closely related to certain physical dimensions and characteristics of the human body such as weight, volume, center of gravity, inertial properties of body segments, and strength of muscle groups.

2.6 Pulley

To throw away the rubbish in the rubbish bin, a pulley is needed as an auxiliary tool which will leverage the back of the rubbish bin. A pulley is a wheel that is surrounded by a rope and is used to make human work easier. The load will feel lighter if you use a pulley[12]. The working principle of a pulley is to pull or lift an object using a wheel or axle so that it feels lighter.

There are three types of pulleys, namely fixed pulleys are pulleys that rotate only on their axis and cannot move freely, then free pulleys are pulleys that rotate on their axis and can move up and down. The free pulley has the principle of working from the beginning to the end of the load on the pulley. And taking the data is between the fulcrum and the power point, so that the force exerted is only half of the load being lifted, then a compound pulley is a pulley that has more than one pulley, so the advantage of this pulley is calculated from the amount of load lifted[13]. The pulley used in this research uses a fixed pulley.



Figure 1. Fixed pulley

To get the maximum load that can be lifted by a pulley, a calculation formula is needed. The fixed pulley calculation formula is:

$$W \cdot l_b = F \cdot l_k$$

Information :

w = object weight (N)

l_b = load arm (m)

F = force (N)

l_k = power arm (m)

Because the load arm is the same as the power arm (l_b = l_k), the power force is the same as the load being lifted, formulated:

$$F = W$$

3 METHODOLOGY

3.1 Research procedure

This research methodology is presented in the form of a flowchart. The steps of this research are as follows:

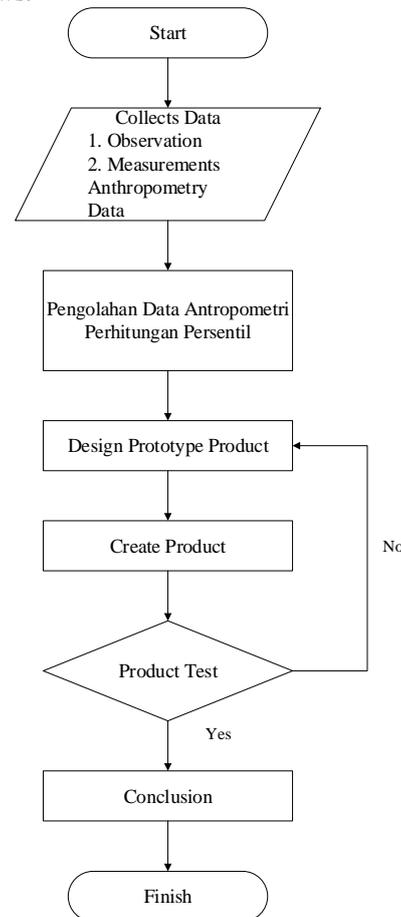


Figure 2. Flowchart of research methods

3.2 Location and Time of Research

This research was conducted at Pahlawan Tuanku Tambusai University in the Industrial Engineering Study Program, Faculty of Engineering. This research is located at Jalan Tuanku Tambusai, Bangkinang Kota District, Kampar Regency, Riau Province. Research time starts from data collection to data processing which will be carried out starting in early January 2022.

3.3 Design Model

The design of the trolley has several considerations, namely from the data used, because the data taken is data on the dimensions of the human body, and everyone has different body dimensions. Selection of materials that are more ergonomic in design.

3.4 Design Data Collection

There are 2 ways to collect this data, namely literature study and data collection in the field. Literature study was carried out as the first stage with the aim of understanding the basic theories and theoretical calculations which are seen from previous research relating to the design and manufacture of

trolleys. While the collection of technical data obtained by conducting research directly.

3.5 Design Data Processing

There are several ways to collect this data, namely:

Stage 1. Anthropometric data collection

This step aims to collect anthropometric data that will be used as a reference for designing the trolley that will be made. By collecting quantitative data by measuring the body dimensions of industrial engineering students class of 2018 to obtain anthropometric data.

Stage 2. Anthropometric data processing

This step aims to find out how many percentiles of each body dimension variable that have been obtained in the previous data collection, the results of the percentiles that have been obtained will be used as a reference in designing ergonomics-based garbage collection trolleys. This data processing uses SPSS 16.0 software. In processing this data, what is sought is the percentile value.

Stage 3. Product design

This stage aims to design a trolley product with reference to anthropometric data that has been obtained and processed, and also to think about the ergonomics aspect. This design process uses AutoCad 2007 software.

Stage 6. Product creation

At this stage all the data that has been obtained before will be realized in physical form at this stage.

Stage 7. Product testing

At this stage the finished product will be tested, this test aims to see whether the product is in accordance with the previous design, the product will be tested whether it can be used and there is also a pulley test to find out the maximum load that can be transported, and to find out Is the product in accordance with the ergonomics aspect?

Stage 8. Conclusion

At this stage it will contain a description of the conclusions from the design, manufacture to the testing process to make the trolley.

4 RESULTS AND DISCUSSION

4.1 Data Collection

This research was conducted at Pahlawan Tuanku Tambusai University in the Industrial Engineering Study Program, Faculty of Engineering. Quantitative data collection was carried out by measuring the body dimensions of industrial engineering students class of 2018 to obtain anthropometric data Body dimension measurements and interviews were conducted with 20 people respondents consisting of 10 industrial engineering students class 2018 and 10 random respondents with an age range of 22 - 57 years.



Figure 3. The process of measuring body dimensions

Data collection was also carried out using the observation method.

Observations were made in Bangkinang City such as campuses, houses and parks. Observations were made by measuring the dimensions of the length and width of the trash bins, and the capacity of the trash bins. The results of the observation of trash bins found that 3 types of trash bins with different lengths and dimensions as well as their capacity were found around Bangkinang city which consisted of net trash bins, small trash bins, large trash bins. For net trash cans that can be found around the campus environment, small trash bins can be found in parks around the campus environment, and large trash cans can be found in housing areas around Bangkinang City.

Table 1 Observation of trash

| Trash type | Quantity | Trash Bin Capacity | Trash Can Size |
|--|----------|--------------------|--------------------|
|  | 3 pieces | 10 Liter | 5cm x 5cm x 26.3cm |
|  | 4 pieces | 42 Liters | 2cm x 32cm x 67cm |

| Trash type | Quantity | Trash Bin Capacity | Trash Can Size |
|---|----------|--------------------|---------------------|
|  | 6 pieces | 70 Liters | 6 cm x 33cm x 70 cm |

Based on table 4.2, it was found that the most widely used bins by the people of Bangkinang Kota with a quantity used of 6 pieces were 70 liter bins with a height of 70 cm, a width of 33 cm and a length of 46 cm, so the bins that fit this trolley is a large trash can.

The aspects measured in measuring body dimensions include standing waist height, forward reach of the arms, shoulder width, and palm length. Data processing

Data processing in this study using the SPSS 16.0 application, this data processing aims to find the percentile value of each body dimension measurement variable, the percentile value from the results of data processing is used as a size reference in the design to be made.

Table 1. Body dimension variable percentile value

| | TB | TPB | JTD | LB | PTT |
|---------|--------|--------|-------|-------|-------|
| Valid | 20 | 20 | 20 | 20 | 20 |
| Missing | 0 | 0 | 0 | 0 | 0 |
| 5 | 150.00 | 80.25 | 63.10 | 36.05 | 16.00 |
| 10 | 150.30 | 85.50 | 65.20 | 37.20 | 16.00 |
| 50 | 165.00 | 95.00 | 74.00 | 44.00 | 17.00 |
| 90 | 170.00 | 99.90 | 75.00 | 46.00 | 18.00 |
| 95 | 170.00 | 101.90 | 76.90 | 50.75 | 18.95 |

The calculation of the percentile according to the 4 measurement data used in the design of the trash can transport trolley is as follows:

1. Shoulder Width (LB) is applied in this design as the width of the trolley which will use the 50th percentile with a width of 44 cm.
2. Waist Standing Height (TPB) is applied in this design as the height of the trolley which will use the 95th percentile with a height of 101.90 cm.
3. Forward Hand Reach (JTD) is applied in this design as the distance of the trash can which will use the 5th percentile with a length of 63.10 cm.
4. Palm Length (PTT) is applied in this design as the diameter of the trash can holder which will use the 5th percentile with a diameter of 16 cm.

4.2 Product Design

The product design process uses AutoCad 2007 software, the design aims as a reference in the product manufacturing process so that there are no errors in the manufacturing process such as measurement errors and material cutting.



Figure 4. Design of a trash can carrier trolley

In the design of this trolley add several specs to the design of the trolley to be made, namely:

1. Added 3-sided wheels on the back of the trolley to make it easier when you want to climb stairs.
2. Added a pulley to the handle of the trolley, making it easier to transfer to a temporary waste disposal site (TPS).
3. This trash can transport trolley is designed according to the anthropometry of the human body so that it is comfortable and safe when used.

4.2 Test

The test is carried out with the aim of knowing whether the trolley product is feasible or not, it is necessary to carry out a testing process. The tests to be carried out on this product are as follows:

a. Pulley test

The pulley test is carried out to find out the maximum load that can be lifted by the pulley so that the back of the trash can lift. Giving a pulley aims to facilitate the process of disposing of waste to the TPS. To find out the maximum load that can be lifted by the pulley, it is necessary to test using the single fixed pulley formula,



Figure 5. Pulley testing process

The following is the calculation of the maximum pulley load using the formula
 $W \cdot l_b = F \cdot l_k$

$$\begin{aligned} W \cdot 1 \text{ m} &= 10 \text{ N} \cdot 1 \text{ m} \\ W \cdot 1 \text{ m} &= 10 \text{ N} \\ W &= 10 \text{ N} \end{aligned}$$

So based on the calculation results, the maximum load that can be lifted by the pulley is 10 Kg.

b. Test physical product

The physical product test is carried out by trying the trolley that has been made, the physical product test includes trying the pulley mechanism whether it works properly or not, trying the trolley wheels according to what is planned or not.



Figure 6. Physical product testing process

The picture above is a trial run on the stairs to try the rear wheels, because the rear wheels are made of 3 axes to be able to climb the stairs. Based on the test results, it was found that the rear wheel works according to the design, so the trolley is easy to lift and carry through the stairs to reduce pain. injury to the muscles, tendons, ligaments, nerves, cartilage, bones, or blood vessels in the hands, feet, neck, and back.

c. Test capacity

The capacity test is carried out to determine the amount of capacity lifted by the trash can, the capacity test is carried out with 3 types of tests, namely the light load test, the moderate load test, and the heavy load test.



Figure 7. Capacity testing process

The light load test was carried out by putting 2 Kg of garbage into the trash and throwing it into the TPS, based on the light load test, it was found that turning the pulley did not require a large amount of power, and the trolley was still able to lift it to the TPS.

The test with a moderate load was carried out by putting 5 Kg of garbage into the trash and throwing it into the TPS, based on the test with moderate load, it was found that turning the pulley did not require a large amount of energy, and the trolley was still able to lift it to the TPS.

The test with a heavy load was carried out by putting 10 kg of trash into the trash and throwing it into the TPS, based on the test with a heavy load it was found that rotating the pulley required considerable power, the trolley was still able to lift it to the TPS

5 CONCLUSION

Based on the formulation of the problem in this thesis entitled "Design of Ergonomics-Based Garbage Trash Transport Trolley Based on Anthropometric Data" the authors can conclude as follows:

1. The design and manufacture of trolleys according to the anthropometric size of the human body where the trolley is very functional by providing pulleys on the trolley so as to facilitate the process of transferring to the four temporary waste disposal sites (TPS) and providing 3-axis wheels which function to facilitate waste collection via stairs. Thus reducing complaints of diseases such as injury to the muscles, tendons, ligaments, nerves, cartilage, bones, or blood vessels in the hands, feet, neck, and back.
2. The physical product of the trolley is in accordance with anthropometric aspects and also the trolley becomes more efficient in its use.

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