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CONCEPTUAL DESIGN APPLIED IN THE DEVELOPMENT OF AN ERGONOMIC WHEELBARROW

Franco da Silveira: franco.da.silveira@hotmail.com; UFRGS
Filipe Molinar Machado: fmacmec@gmail.com; URI
Jonathan Cadernal dos Anjos Steinhaus: jonathan_ca08@hotmail.com; URI
Fernando Gonçalves Amaral: amaral@producao.ufrgs.br; UFRGS
Leonardo Nabaes Romano: romano@mecanica.ufsm.br; UFSM

ABSTRACT

In the civil construction sector, an important piece of equipment is the wheelbarrow. The activities carried out by the civil construction operators are facilitated in such scenarios that require materials transportation using the wheelbarrow. However, there is an information gap that seeks alternatives for types of wheelbarrow considering ergonomics scope and operations facilities. In this context, the article consists of presenting a concept of ergonomic wheelbarrow. In the methodology, a semi-structured questionnaire was applied to 20 workers from a construction company. As a result, the study presented a conceptual design of an ergonomic wheelbarrow, solving the needs observed by operators, aiming to propose a product that reduces efforts, through a safe operation and reducing the time to perform tasks.

KEYWORDS: wheelbarrow; ergonomics; product concept

1. INTRODUCTION

The products are constantly changing and increasingly adapting to the needs of their consumers. Thus, many companies seek to develop new products, but the results are not always satisfactory, and they end up not being successful in sales (LEE et al., 2018). For a company to achieve satisfactory results in the competitive market in which they operate, it is important to identify the needs of consumers, define a systematic approach to technical requirements, and express what critical points the business solution aims to address.

In this context, developing products that require high quality and greater efficiency in their production processes is a complex task (SILVEIRA et al., 2018). For example, in the construction industry, a vitally important piece of equipment is the wheelbarrow. The activities performed by workers using the wheelbarrow are facilitated in scenarios that require the transportation of materials (such as carrying loads of bricks, cement, soil, and concrete). Standardizing 50-kilogram cement bags for logistical reasons by manufacturers and intermediaries, it is challenging to investigate and propose alternatives for a wheelbarrow that considers the scope of ergonomics and facilitates the operator's work (PEREIRA et al., 2015).

In construction, activities require effort and physical strain on the operator, who is at risk of accidents. An example of a risk is when climbing ramps with a wheelbarrow full of soil or concrete, where operators may neglect using side protections to prevent falls. Combining this neglect with the physical strain generated by repeatedly performing these activities increases the likelihood of accidents. Although manufacturers of this equipment strive to produce it with quality and safety, there are still factors and components that can be improved in the development of an ergonomic product (SILVA et al., 2015).

2. OBJECTIVE

The article aims to propose a concept for an ergonomic wheelbarrow designed for construction workers. It examines the products available in the market, gathers technical specifications to find a solution to ergonomic issues, and enhances usability for the operator. Ergonomic factors of the presented wheelbarrow concept are discussed.

3. METHODOLOGY

The study adopted the methodology proposed by Romano (2013) to define the steps to be executed. The application began with the informational design phase, involving needs assessment, understanding of ergonomic issues, verification of technological information and competitor products, translation into technical requirements, and concluding with meta-specifications. Subsequently, the conceptual design phase describes the technologies, operating principles, and forms of a product, expressed through a scheme or three-dimensional model and textual explanation.

In this study, solutions were partly found through the observation of competitor products and research in 18 catalogs, 9 technical magazines, and 22 websites of wheelbarrow manufacturing companies. The research involved a total of 20 interviewed individuals, consisting of 12 laborers and 8 masons responsible for transporting loads using a wheelbarrow. A semi-structured questionnaire was used for the interviews to identify

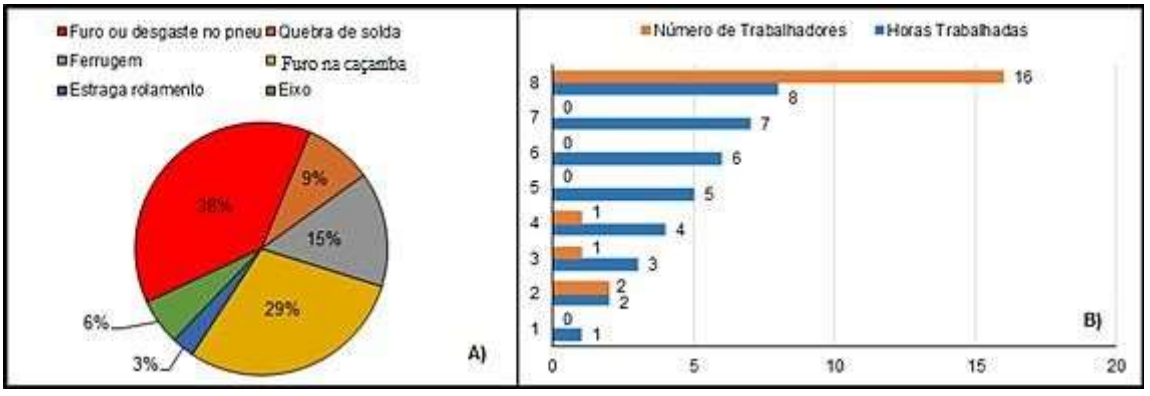
technical factors to be considered in the ergonomic wheelbarrow.

4. RESULTS

4.1. Interviews and Attribute Collection

Figure 1 (A) highlights that 38% of the issues with the wheelbarrow are related to punctures, tire wear, and structure rust.

Figure 1 – A) Defects in the use of the wheelbarrow; B) Operating time.



These factors assist in identifying problems that need to be addressed by the concept of an ergonomic wheelbarrow. According to Figure 1 (B), the responses varied, with 5 expressing difficulties in exerting effort when handling the wheelbarrow on ramps. For 8 interviewees, difficulties were identified when unloading concrete, as the required weight to lift the wheelbarrow and concrete, along with the use of a shovel to remove the content (the corners and screws in the bucket do not remove all the material). For 7 interviewees, the stability of the wheelbarrow is poor, as if it tilts to one side, it hinders balance and may cause the entire load to fall. Another complaint relates to the tire that punctures quickly, and there are many problems when trying to replace it. The screws that hold the tire fill with grease, making them difficult to remove, and there are also issues with the axle. The interviewed workers stated that it is difficult to steer and maneuver the wheelbarrow by the handles. They are short or straight, causing the operator to stumble when transporting it.

Furthermore, in Figure 1 (B), the majority of interviewees use the wheelbarrow for 8 (eight) hours a day, confirming the product's utility. When asked whether the operator's choice of a wheelbarrow is related to low cost, agility, safety, or durability, it was found that 40% emphasize choosing a wheelbarrow that provides ergonomic safety, placing the other options

in the background, each representing 20%.

Analyzing the technical attributes of wheelbarrows, Table 1 lists the design requirements that are considered important for both operators and manufacturing companies (based on information available in catalogs and websites).

Quadro 1 - Atributos técnicos do carrinho de mão.

Basic Attributes	Operation	Ease of Use
		Easy Material Discharge
		Rust Protection
		Safe System for the Operator
	Ergonomics	Weight of the equipment and maneuverability
		Requires little physical effort for displacement
		Allows good posture for the operator
		Prevents lower back and joint injuries
	Economic Attributes	Equipment and component lifespan
		Production cost
	Safety	Safety system
		Resilient components
	Materials	Durable and lightweight materials
		Standardized materials readily available in the market
Life Cycle Attributes	Usability	Easy to maneuver
		Easy assembly or disassembly
		Facilitates quick component replacement
	Maintainability	Easy maintenance with accessible exchange points
	Environmental Impact	Facilitates cleaning and disposal of used components

4.2 Ergonomic Technical Aspects

Ergonomics is a distinctive aspect assigned to the product in its development phase once the solutions for the product functions are defined, following the operating parameters. The main goals of ergonomics are to increase organizational efficiency and enhance the safety, health, and comfort of the operator. For this to be possible, a study is required regarding the postures adopted by workers, body movements performed, environmental physical factors framing the

work, and equipment used, with the goal of reducing hazards and preventing errors and accidents.

Handles: the handle of the conventional wheelbarrow is fixed, and there is no way to change its position, making it lower or higher, as well as longer or shorter. Operators do not have the same physical stature; therefore, a wheelbarrow may be ergonomically suitable for one operator but not for another. The solution found was to create an adjustment system on the arms of the wheelbarrow that allows it to be raised or lowered. A system with perforation and pin was chosen for this purpose. This way, the operator can adjust the wheelbarrow arm according to their desired height, providing them with greater comfort.

Single-wheel balance: besides the effort required to push the wheelbarrow, the operator must also keep it balanced on the front wheel, which demands effort and often leads to complaints from workers. The solution was a wheelbarrow with three wheels, with the front wheel being the same as the conventional one, and at the back, instead of feet, two wheels were placed, with a smaller diameter than the front one. These wheels have a swivel base to make it easier to maneuver the wheelbarrow. This reduces the efforts required in using the wheelbarrow, as the operator only has to push it. It also increases safety since there is no need to balance it, improving stability when maneuvering the wheelbarrow.

Material unloading mode: there is difficulty in unloading the material without lifting the wheelbarrow. It was decided to change its geometry and divide it into two parts to facilitate the operation. To unload, simply move the bucket, not the entire wheelbarrow, aiming to reduce efforts and working time. To unload, the operator needs to engage the rear brake to prevent it from moving (explained further about the brake). After activating the brake, the worker should position themselves on the side of the wheelbarrow and move the bucket. This way, the worker's effort will be less because they don't have to propel the entire wheelbarrow, reducing the necessary force as they only need to move the bucket.

Ramp ascent: another factor considered is the need to climb some type of ramp. With a three-wheel system, it will not be possible to balance the load as with a conventional wheelbarrow, where the operator lifted and lowered the load when necessary. For this, a crank system was used, providing a slight tilt to the bucket when necessary.

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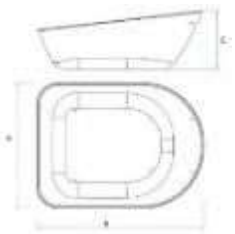
4.3 Detailed Components of the Ergonomic Wheelbarrow

In Table 2, all proposed technical changes are listed, representing the outcome sought by this present work. This concludes the conceptual design phase, encompassing all desired

concepts, forms, potential dimensions, materials, and technical functionality.

Table 2 – Detailed Components of the Ergonomic Wheelbarrow

Component	Illustration	Technical Description	Functionality
Bucket		Deep metal bucket. 70 L volume. Galvanized steel sheet. 0.9 mm thickness. Powder-coated finish with electrostatic paint. Approximate dimensions: A x B x C (660 x 915 x 222) mm.	Bucket is more resistant due to its thickness. Resistant to oxidation (galvanized steel and coated with special corrosion-resistant paint).
Chassis (Upper Part)		Tubular metal chassis. Galvanized steel. Tube diameter (31.75mm). 1.5 mm thickness. Powder-coated finish with electrostatic paint.	Allows it to have 3 wheels, cable adjustment, and enables the fitting of chassis part 2.
Chassis (Lower Part)		Tubular metal chassis. Galvanized steel. Tube diameter (31.75mm). Thickness of 1.5 mm. Powder-coated finish with electrostatic paint.	Allows for better unloading of the bucket's contents as it is movable, making it possible to unload without the need to lift the wheelbarrow..
Screw Protective Cover		Polypropylene material. Hexagonal hole of 13 mm.	Protects the bolts and nuts, preventing the accumulation of debris that may hinder their removal.

Adjustment System on Arms		Galvanized tubular arm. Tube diameter 28.75mm. Thickness of 1.5 mm. 6 holes, with a diameter of 8 mm. Dimensions 300 x 250 mm.	Allows for the adjustment of the handle height according to the physical build and needs of the operator.
Safety Lock		Polypropylene and steel pin. Internal diameter of the Polypropylene part is 31.75 mm. Steel pin with a diameter of 8 mm.	Its function is to lock the wheelbarrow arm.
Quick-lock for the Chassis		Quick-release zinc-plated latch. Dimensions LxWxH (15 x 10 x 5) mm.	Allows for the quick fixation of chassis part 1 to part 2, providing greater security during the transport of the load.
Crane for adjusting the Bucket		Metal crank. Steel screw with 10 mm thread.	The crank allows for the adjustment of the bucket when necessary.
Front Wheel		Swivel wheel with tire. Total height with base and wheel is 22 cm. Tire diameter is 15 cm. Width is 4.5 cm. Supports a load of 150 kg.	The wheels will allow the cart to be supported on them, reducing physical effort.
Rear Wheel		Metal wheel. Tire with inner tube 3.25/8". Diameter of 360 mm. Width of 75 mm.	The tire with inner tube provides better cushioning when performing tasks.
Sistema de freiodianteiro		V-Brake brake. Aluminum material. Geometry found in the market.	The front brake will allow braking when necessary.
Sistema de freiotraseiro		Quick-release brake. Polypropylene material. 4.5 cm width (surface that will come into contact with the tire).	The brake will allow the wheelbarrow to be locked in place for the necessary time.

A Figura 2 illustrates the ergonomic wheelbarrow after assembly with the items described in Table 2.

Figure 2 - Proposed concept of an ergonomic wheelbarrow.

Após todas as alterações apresentadas, encerra-se a fase do projeto conceitual. Se a proposta de construir o carrinho de mão ergonômico for adotada, deve-se dar continuidade com a realização do projeto detalhado, que deverá conter todos os cálculos de resistência, as especificações dos materiais e todas as dimensões.

5. CONCLUSION

The study presented viable and suitable solutions within the project proposal, aimed at solving the observed problems with practical solutions. It is believed that by implementing the solutions presented, it is possible to significantly increase worker safety, as the three wheels enhance stability and reduce physical effort. Another important factor relates to the alterations made to the structure, which should provide ergonomic improvements to the product, as it will not be necessary to lift the wheelbarrow, and it will be possible to adjust the arms. It is suggested to construct a prototype of the ergonomic wheelbarrow, which would validate the results presented in the conceptual design project.

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