DEVELOPMENT OF LOW-COST BENCH TRIBOMETER FOR WEAR TESTS BY SLIDING.

Samara Rebeka Pita Maciel [a], Lucas Gabriel Leite Bostock [a], Juliana Ricardo de Souza [a], Camila Ferreira Escobar [a], Nilmar de Souza [a].

[a] Centro de Ciência e Tecnologia em Energia e Sustentabilidade- UFRB, Av. Centenário,697, Sim, Feira de Santana- BA,44042-280.

Abstract: Given the current demands in developing novel materials for applications that necessitate effective surface interactions during contact, it becomes apparent that comprehending the friction behavior of material pairs and products using laboratory equipment like tribometers and wear simulators holds significant value in research endeavors. Practically speaking, these requirements span across various fields, from medical and dental domains, where the rise in implant usage and the need for reoperations due to prosthetic wear become crucial, to the overall service life of materials and components. Contact mechanics and tribological performance find applications in diverse sectors of society. Aiming to provide a simple and low-cost method to evaluate wear in different materials, a benchtop tribometer prototype was developed to perform wear tests by sliding, through the handmade methodology.

Keywords: Tribology; Materials Characterization; Contact Mechanics.

DESENVOLVIMENTO DE TRIBÔMETROS DE BANCADA DE BAIXO CUSTO PARA ENSAIOS DE DESGASTE POR DESLIZAMENTO.

Resumo: Dadas as necessidades atuais no desenvolvimento de novos materiais voltados para aplicações que exijam bom desempenho mecânico de resistência ao desgaste quando suas superfícies estejam sob atrito, é cada vez mais necessário o uso de técnicas de caracterização tribológica, que pode ser realizado com equipamentos de laboratório dos tipos: tribômetros e simuladores de desgaste. Essas necessidades envolvem aplicações que vão desde as áreas médica e odontológica, com o aumento do número de implantes e a necessidade de reoperações, devido ao desgaste, tal como em relação à vida útil em serviço de materiais e componentes mecânicos. A mecânica do contato e o desempenho tribológico encontram aplicações em diversos setores da sociedade. Visando proporcionar um método simples e de baixo custo de avaliar o desgaste em diferentes materiais, desenvolveu-se um protótipo de tribômetro de bancada para realizar ensaios de desgaste por deslizamento, através da metodologia *handmade*.

Palavras-chave: Tribologia; Caracterização de Materiais; Mecânica do Contato.

1. INTRODUCTION

Since the dawn of humankind, the interaction between humans and nature has always been in constant evolution, aiming to utilize tools to strategize ways to reduce losses or increase the lifespan of materials and mechanical components, applied across various sectors of society. This interaction has gradually evolved through different strategies that continue to have significant impacts on the national economy, affecting maintenance costs due to part replacements and energy consumption caused by friction within systems [1]. As a result, the repercussions of equipment and device failures prompt us to proactively anticipate system breakdowns, leading to interventions to implement, create, and extend the well-being of people worldwide.

Since the 20th century, human systems of mobility, energy, and built environments have required an intensified use of the scientific method to process, characterize, and systematically test the approximately one hundred thousand structural materials currently employed in engineering projects. However, this scenario was different five centuries ago [2]. The primary objective of Engineering is to produce a machine or system that meets specific specifications and performs a given function. In the early history of Engineering, as described by DOWSON (1997), this objective took precedence, with considerations about friction, wear, reliability, and other efficiency-related aspects being secondary [3].

In most cases, wear is detrimental, leading to increased play between moving components, unwanted movement, and reduced accuracy [4]. According to LUZIA (2022), tribology in its conventional form, has been studied since the beginning of human history [5].

The ever-increasing dynamic demands of structural materials in Engineering applications and the complexity of the tensor fields of tensions and deformations acting on contemporary structures have necessitated in-depth studies of the properties of these materials [2]. Consequently, numerous techniques and devices are used to assess friction and wear to which components may be subjected. Wear tests encompass a set of procedures performed to simulate and study the accelerated degradation of mechanical components through laboratory practices.

For modern engineers, understanding the physical nature of friction, defining wear, comprehending its consequences, mechanisms, and methods to control its effects are essential. With the need to maintain the integrity of tools, scientists and production engineers have been seeking new methods to measure tool wear. Tool wear is influenced by various factors in day-to-day use, such as temperature, force, torque, and others [2].

Tribometers are often used to obtain friction coefficient parameters and tribological characterization [6]. So, given the lack of bench equipment, he opted for the handmade methodology, which favors the strong interaction between theory and practice, teamwork and critical and permanent evaluation. In this way, the objective was to develop a simple and traditional engineering prototype with easy possibility of use, if adapted and measured for the tribological characterization of materials.

2. METHODOLOGY

Initially, the test configuration of the developed tribometer was established based on the relevant literature available during the research phase.The preliminary design of this equipment involves creating a benchtop tribometer device, where diverse wear tracks are affixed to its surfaces using sandpaper with varying granulometries. These tests are conducted to evaluate wear resulting from sliding friction, aiming to quantify the mass loss and thereby elucidate the behavior of different materials under such conditions.

Certain requirements were identified as crucial:

1. The equipment should have a user-friendly and straightforward handling system to facilitate cost-effective tests for the entire academic community and beyond.
2. The apparatus must be designed in a manner that allows for easy replacement of specimens and sandpaper affixed to the tribometer's surface.
3. The device should be capable of operating with adjustable contact pressures and speeds to best suit the intended testing scenarios.

The bench tribometer was designed and developed at UFRB (Universidade Federal do Recôncavo da Bahia) and made available to the academic community, with the valuable collaboration of professors, researchers, and students.

For the structural assembly of the project, the process commenced with the characterization of the car and other components manufactured using 3D printing or additive manufacturing (AM) techniques, utilizing thermoplastic PLA as the raw material. This manufacturing process allows for the high-quality 3D printing of intricate parts in various sizes with exceptional efficiency, emphasizing reduced material wastage, design flexibility, and lower costs. A comprehensive list of all the materials used in the design and construction of the tribometer is provided in Table 1 below.

Table 01: Materials used in the Project

Materials used in the Project	
Software Tool	**Model**
CAD software	Solidworks Premium 2018
Slicing Software	3D Ultimaker Healing (version 5.1.0)
File Format	STL
Manual tool	
3d printer	Creality CR-10
Filament	PLA

3. RESULTS AND DISCUSSION

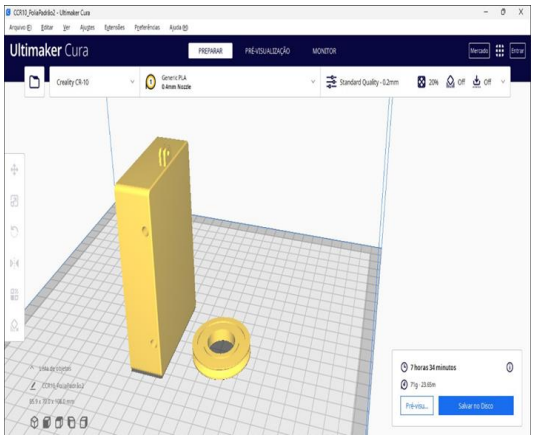
This project focuses on the Design, simulation, and prototyping of a tribometer equipment. The primary goal of this endeavor is to achieve a low final acquisition cost, enabling its use for wear data collection.

In this context, activities such as categorizing and systematizing complementary data within the project's structure, conducting logistics, market research, and material procurement, 3D printing of devices and tribometer parts, assembling the structure, and conducting a bibliographic review were accomplished during the development of this project.

3.1 Prototype Manufacturing:

The model was developed using CAD software in order to obtain the file in STL format. Then, the product was sliced and printed, as can be seen in the Figure 1.

Figure 1: 3D model in the Ultimaker Cura software



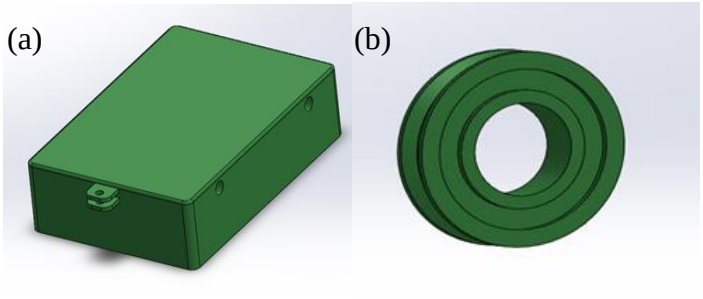
In this project, the 3D Printer was used: Creality CR-10, which is a practical printer for assembly and quick to perform tasks.

The filament used in the project was PLA, normally its temperature ranges from 200 to 210°C and on the table it can range from 50 to 60°C. The main features are excellent adhesion between layers, high visual quality and ease of printing on any open or closed printer compared to other filaments such as ABS.

3.2 Model Demonstration

In Figures 2 (a) and (b), there is a representation of the parts manufactured by 3D printing, in the CAD software.

Figure 02 (a) 3D model of the test car base and (b) the pulley.



(Source: Elaborated by the author, 2023)

3.3 Result Obtained by 3D Printing

Below at the Table 2, result obtained from the 3D printing software Ultimaker Cura (version 5.1.0):

Table 2: Results obtained by 3D Printing

RESULTS OBTAINED BY 3D PRINTING	
Data	Results
product dimensions	108x70x26 mm (Car base) / 46.18x22x7 mm (Pulley)
Material used	PLA
Worn filament length	23.65 m
Final prototype weight	71 g
Extruder nozzle temperature	200 °C
Print table temperature	50 °C
Fill	20%
Retraction Speed	45 mm/s
print time	7 hours 34 minutes

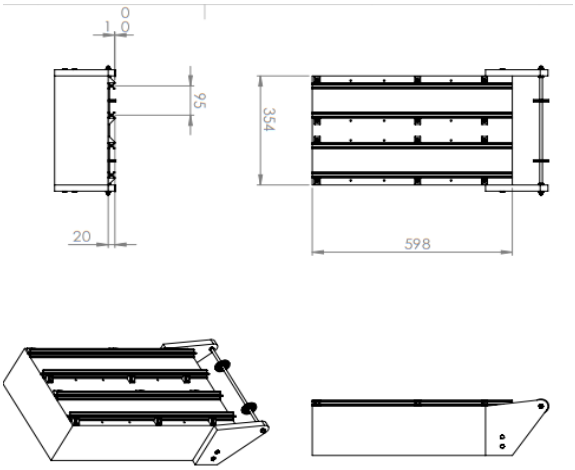
From the models generated in 3D for the impressions of the specimens and the manual construction of the structure for the experimental apparatus, the sample holder and the sliding pulley, Figure 3, were manufactured.

Figure 3: (a) Sample Holder and (b) Pulley.

(Source: Elaborated by the author, 2023)

The schematic drawing of the tribometer can be seen in four views in Figure 4.

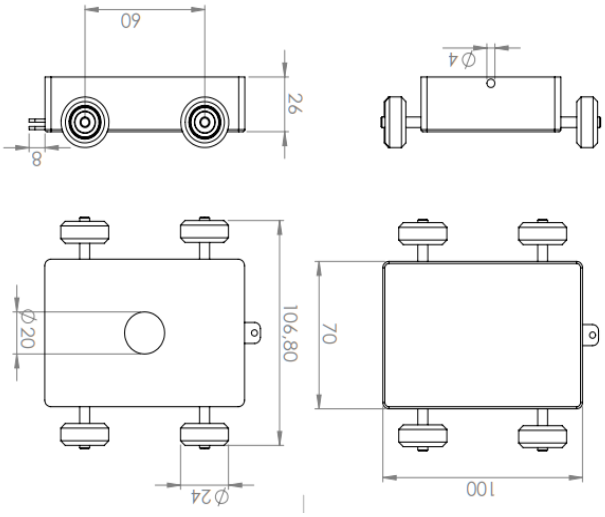
Figure 4. Schematic Drawin of the Tribological



(Source: Prepared by the authors, 2023)

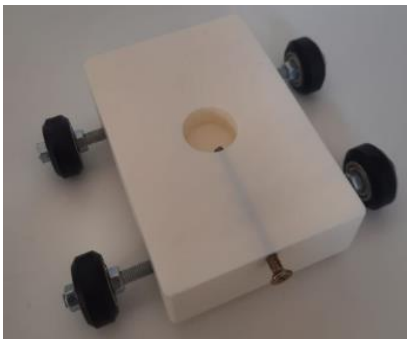
For the effective sliding of the specimens, a sample holder was designed, Figure 5 and 6, for 3D printing with sufficient dimensions to fit it in the wear tracks of the tribometer.

Figure 5. Sample port modeling



(Source: Prepared by the authors, 2023)

Figure 6. Sample holder printed



(Source: Elaborated by the author, 2023)

4. CONCLUSION

The tribometer was obtained from the 3D design models created for printing the test specimens and manually constructing the bench structure. Additionally, successful progress was made in categorizing and systematizing additional data within the project's structure, conducting logistics, market research, and material procurement, as well as printing and assembling the tribometer device. Consequently, the equipment's structure was designed and completed manually.

The next stage of the project involves operating the tribometer, conducting sliding tests using the specimens on its contact surface to quantify the mass loss.

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