HYDRAULIC PROPELLER PROTOTYPING WITH 3D PRINTING

PROTOTIPAGEM DE HÉLICE HIDRÁULICA COM IMPRESSÃO 3D

PROTOTIPADO DE HÉLICES HIDRÁULICOS CON IMPRESIÓN 3D

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ABSTRACT

3D Printing is an elementary tool for the free fabrication of objects that can be used in factory, commercial, academic and domestic scales. The technology has a low cost and high efficiency in the production of parts, which justifies its wide application. In order to manufacture a propeller for use in hydraulic benches, the object is modeled with a Revit tool and manufactured with a 3D printer. ABS is the material chosen for prototyping because it is the lowest cost and because it provides good mechanical resistance, although it requires attention regarding workability. In order to explore the best performance of the ABS material, a tensile test is carried out on Test Specimens (CP) manufactured with different filament deposition modes and compared to the values indicated by the manufacturer. Despite the mechanical resistance approaching ¼ of the indicated value, the behavior of the propeller in the reduced-scale hydraulic channel and the aesthetics of the object were satisfactory. However, the difficulty in obtaining the expected result is highlighted, due to the lack of maintenance on the printer and the complexity of modeling the part, since the part requires in-depth techniques of the modeling tool.

Keywords: 3D Printing. Hydraulic. Engineering. Propeller. ABS.

RESUMO

A Impressão 3D é uma ferramenta elementar para a livre fabricação de objetos que pode ser utilizada em escalas fabris, comerciais, acadêmicos e domésticos. A tecnologia apresenta baixo custo e elevada eficiência na produção de peças, o que justifica sua ampla aplicação. Com o objetivo de fabricar uma hélice para utilização em bancadas hidráulicas, modela-se o objeto com ferramenta Revit e fabrica-se com a impressora 3D. O ABS é o material escolhido para a prototipagem por ser o de menor custo e por conferir boa resistência mecânica, embora exija atenção quanto a trabalhabilidade. Para explorar a melhor performance do material ABS, executa-se ensaio de tração em Corpos de Prova (CP) fabricados com diferentes modos de deposição do filamento e compara-se aos valores indicados pelo fabricante. Apesar da resistência mecânica aproximar-se de ¼ do valor indicado, o comportamento da hélice no canal hidráulico de escala reduzida e a estética do objeto foram satisfatórios. Entretanto, ressalta-se a dificuldade em obter o resultado esperado, pela ausência de manutenção na impressora e a complexidade da modelagem da peça, uma vez que a peça requer de técnicas aprofundadas da ferramenta de modelagem.

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Palavras-chave: Impressão 3D. Hidráulica. Engenharia. Hélice. ABS.

RESUMEN
La impresión 3D es una herramienta fundamental para la fabricación libre de objetos que pueden utilizarse a escala industrial, comercial, académica y doméstica. Esta tecnología ofrece un bajo coste y una alta eficiencia en la producción de piezas, lo que justifica su amplia aplicación. Para fabricar una hélice destinada a bancos hidráulicos, el objeto se modela con Revit y se fabrica con una impresora 3D. El ABS es el material elegido para el prototipado por su menor coste y su buena resistencia mecánica, aunque requiere una trabajabilidad cuidadosa. Para explorar el mejor rendimiento del ABS, se realizan ensayos de tracción en probetas (PC) fabricadas con diferentes métodos de deposición de filamentos y se comparan con los valores indicados por el fabricante. Si bien la resistencia mecánica se acerca a un cuarto del valor indicado, el comportamiento de la hélice en el canal hidráulico a escala reducida y la estética del objeto fueron satisfactorios. Sin embargo, se destaca la dificultad para obtener el resultado esperado, debido a la falta de mantenimiento de la impresora y a la complejidad del modelado de la pieza, ya que requiere técnicas avanzadas de la herramienta de modelado.

Palabras clave: Impresión 3D. Hidráulica. Ingeniería. Hélice. ABS.

1 INTRODUCTION

Second, 3D printing is essential for the free prototyping of objects. It is a versatile technology that can be applied at different scales and environments and has a greater recurrence in biology, chemistry, medicine and engineering. POLITE; LEE; MARQUES, (2023)

In a survey of the State of the Art with bibliometric analysis, based on the keywords "3D printing", "engineering" and "hydraulic", they found that the main lines of research refer to the areas of Biofabrication, tissue engineering, hydraulic structures and biological scaffolding, which confers the scope of the tool. LOPES and MARQUES (2023)

The variety mentioned is illustrated with the divergence of the following applications: the studies of complex hydraulic structures, based on printed models, in reduced scales (, and the teaching of ophthalmology according to , which used computed tomography (CT) to prototype bone and soft structures. LOPES and MARQUES (2023) SASSAKI et al. (2022)

The diversity of the tool is also justified by the range of materials available, which allows the choice of the most suitable filament. From this perspective, they check the materials PLA, ABS, PETG, NYLON, TPE, TPU, TPC and PC as the most recurrent, through bibliometric research and classify them by physical, mechanical, aesthetic characteristics and by cost and ease of use. GRITTEN; BESKO; BILYK, (2017)

The rationale for this work is the significance of prototyping for civil engineering and the benefits that can be obtained through pilot-scale studies. The objective was to obtain a hydraulic propeller manufactured in ABS, based on a three-dimensional design. The methodology is composed with the modeling of the part with the REVIT software, the slicing with the ULTIMAKER CURA and the production using the GTMax H4 Core 3D printer.

2 GOALS

The objective is to manufacture propellers using a 3D printer and to transcribe the importance of modeling and prototyping parts in civil engineering.

3 METHODOLOGY

The methodology of this work is divided into three parts. The first consists of propeller modeling, which uses the REVIT software. The project is developed with a unit of measurement in millimeters, in real scale 1:1 and later, the model is exported in STL format, for slicing.

The second part is done in the ULTIMAKER CURA program, with the slicing of the piece. This process is essential to configure the parameters of density, filling and resistance, finishing, material used (ABS) and adapt the printing according to the GTMax 3D H4 Core printer. The parameters related to the printer are: volume available for printing; table and extruder temperature; GCode programming; Extruder dimensions and quantity.

The third phase refers to the plotting of the parts and consequently applications of the models in hydraulic bench and tensile strength testing.

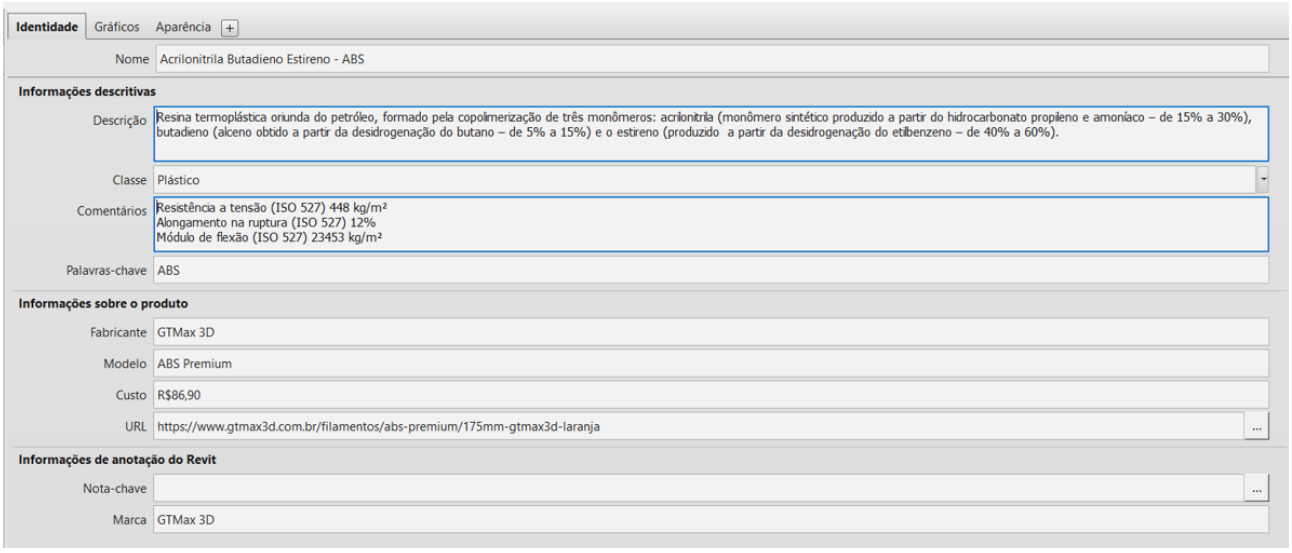
4 RESULTS AND DISCUSSION

The project of the piece was prepared in a REVIT program of BIM (Building Information Modeling) language, which means Building Information Modeling. The base is characterized by representing parameterized three-dimensional models, carrying the respective technical and quantitative data sheets of the project and dialoguing with diverse models and on a universal scale, in IFC format.

In figure 1 you can see the parameters of the material inserted in the model, which describe the chemical composition according to MAIS POLÍMEROS (2018), the mechanical resistance, manufacturer, value and reference of the product, according to . GTMAX (2023)

Figure 1

Model data

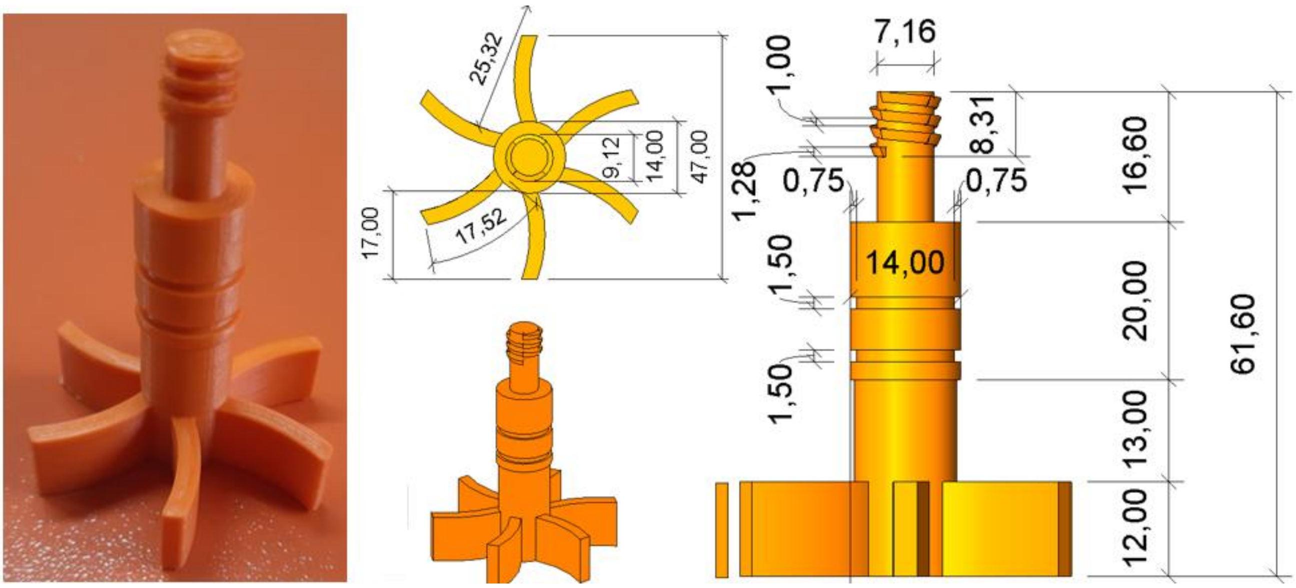


Source: Author.

Figure 2 refers to the manufactured propeller and the design of the part, in which the heights and diameters, the dimensions of the thread for coupling and the curvature of the blades with a cylindrical surface are detailed. In this way, the efficiency of 3D printing is highlighted when observing the millimetric details obtained in the manufactured part.

Figure 2

Hydraulic Propeller

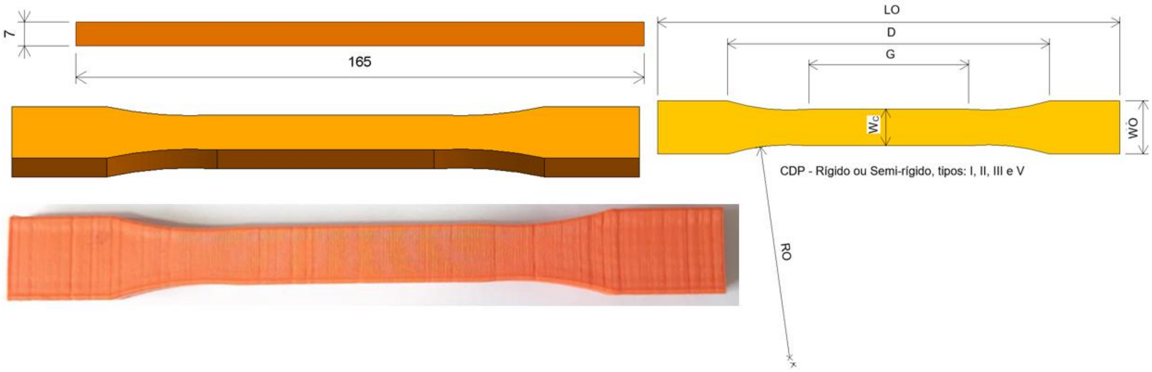


Source: Author.

To verify the tensile strength and compare it to the manufacturer's data, a specimen (CP) was produced with the following parameters according to ASTM D638-14, as follows: thickness (T) at 7 mm, length (LO) at 165 mm and overall width (WO) at 19 mm, length (L) of narrow section at 57 mm and width (W) at narrow section at 13 mm. In the following figure, the specimen made in ABS and the respective project can be observed. "Standard Test Method for Tensile Properties of Plastics 1", [n.d.]

Figure 3

Specimen



Source: Author.

In order for the parts not to peel off during prototyping, it was necessary to apply filament adhesive on the glass plate and after finishing plotting, it is necessary to decrease the temperature, since the base is rigid, so that the material suffers retraction and releases easily.

Although the prototyping achieved the goal of manufacturing the CP, the product illustration showed under-extrusion and over-extrusion through cutters and protrusions in the filament deposition layers. This is because the flow of the filament varies during printing, due to changes in plotting speeds and the dimensions of extrusion height and width. The situation can be corrected by marking the filament flow according to the dimensions mentioned.

The specimens were tested in an EMIC universal machine and presented a maximum tension of 9.98 (MPa) and a maximum force of 1324.51 (N) as illustrated in the following figure.

Figure 4

Essay and report

Corpo de Prova	Seção	Força no Escoamento	Força Máxima	Tensão de Escoamento	Tensão Máxima	Alongamento na Ruptura
	(mm2)	(kgf)	(N)	(MPa)	(MPa)	(%)
CP 1	132.73	123.26	1324.51	9.11	9.98	21.21

Source: Author.

There is a significant disparity in mechanical behavior, if compared to the resistance provided by the manufacturer (448 Kg/m²) and the values found in the gym of 40.2 and 20.59 (MPa) according to JARDIM and MARQUES (2020).

The difference can be justified by the filament deposition pattern and under-extrusion during prototyping. Because the pattern determines how the material is deposited in each layer, and under-extrusion is an unintended consequence of varying filament flow. Thus, both directly influence the gradual adhesion, interfering in the mechanical and aesthetic behavior of the object.

The hydraulic propeller installed in a building system was effective in directing the flow of fluid in the conduit.

It is noteworthy that the arrangement of the propeller blades provided recurrent multidirectional movements of the extruder during printing, and for this reason, the printing speed was reduced from 100 mm/s to 60 mm/s and a considerable amount of adhesive was applied to the base, so that the object did not detach from the glass table and allowed complete printing. The lack of maintenance in the 3D printer used also influenced the flow of the fused filament, which led to the need to clean the nozzle.

5 FINAL CONSIDERATIONS/CONCLUSION

It can be concluded that modeling for construction is an essential tool for the elaboration of various projects, as it has millimetric precision, universal language and is incisive in presenting quantitative, technical data and reference of the materials and objects used.

It is concluded that 3D Printing is a tool of diverse application, because although it has greater recurrence in mechanical engineering, modeling can be used in Civil Engineering, for the production of parts and Specimens, allowing the elaboration of studies and the creation of scenarios.

Although there are different features available in the software itself, the creation of parts using Revit is a feat that requires improved knowledge of the tool, and despite the availability of other tools more appropriate for this modeling, one of the benefits of designing in this software is the connection with the BIM language.

Due to the universality of the language, it was considered necessary to know the materials available on the network. In this scenario, searches of flow machine models were carried out, using the keywords "Turbine", on the following platforms: *3dlibrary, Arcat, Bimbr,* *Bimcatalogs, Bimcontent, Bimetica, Bimobject, Bimstore, Caddetails, Cadforum, Concora, Market.Bimsmith, Modlar, Nationalbimlibrary, Polantis, Prodlib, Revitcity, Specifiedby* and Syncronia. The search presented models of blowers, generators based on Francis and wind turbines, general models of water pumps and exhaust fans. This indicates the relevance of the present modeling in the IFC format. Because the models found have the proper parameters, technical specifications and commercial references, which proves the efficiency of modeling with the BIM concept.

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