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Development of CAD/CAM DESIGN for the Manufacture of a Spring Testing Device

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Abstract

The use of CAD software makes it possible to weigh weights and costs with a high degree of reliability, which facilitates both the reduction of working times and the costs of projects in the general sense and thus obtaining a good cost-benefit ratio.

CAD systems allow the product to be viewed before its manufacture, which assists both in visual and technical issues, such as the operation of

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components in a mechanical assembly, or simply the approval of the "visual" of a product. (Ribeiro J. (2022).

Projects that are developed in teams have many advantages when done in this software because it allows through the internet not only to develop the planned tasks but also to adjust product details of technical meetings to approve or adjust these. This work presents the results of the application of NX Siemens software in the development of the CAD CAM project for the manufacture of a spring testing device. This process was developed using two methods: classic suppressive manufacturing for metal parts and additive manufacturing for parts manufactured with PLA. The results obtained allowed both the development of the CAD project and the manufacture of this device and the tests developed validated the functionality of the device.

Keywords: CAD, device manufacturing, testing, springs.

1. INTRODUCTION

Given the large number of process parameters (Megahed et al., 2016) and their complex interactions, extensive experimental research is needed to ensure flawless production of CAD models via MA, which tends to be expensive. Therefore, MA process modeling not only provides an important insight into the physical phenomena that lead to the final properties of the material and product quality, but also provides the means to explore the design space, aiming to create products and functional materials. The length and time scales required to model MA processes and predict the final characteristics of the part are very challenging.

CAD systems recognized as contributing to innovation in companies, especially in the development of new industrial products in different areas as described by Qiu et al. (2007) .

CAD projects, which in English means Computer Aided Design, are the basis of research and development projects. They allow you to materialize conceptual ideas derived from team meetings and enable a preview of what will be the definitive solution. Currently there are many professional software developed especially for this purpose. (Garcia, et al, 2022)

This work presents the results of the application of NX Siemens software in the development of the CAD CAM project for the manufacture of a spring testing device. This process was developed using two methods: classic suppressive manufacturing for metal parts and additive manufacturing for parts manufactured with PLA. The results obtained allowed both the development of the CAD project and the manufacture of this device and the tests developed validated the functionality of the device.

2. DEVELOPMENT

CAD systems recognized as contributing to innovation in companies, especially in the development of new industrial products in different areas as described by Qiu et al. (2007),

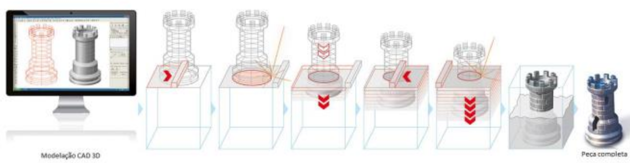
Additive manufacturing (FA) is a term used to group the different manufacturing processes that use various techniques, in which each of them is capable of producing parts made from a wide variety of materials, be they these polymers, ceramics, metals, woods, biomaterials, among others. A brief story on the development of AF can be found in Bourel DLD; J.J. Beaman; Read MC and Rosen DW, (2009).

All these technologies are capable of manufacturing parts by adding material in successive layers, in verse of what happens in more traditional processes, which are considered subtractive, as is the case of machining. These technologies are defined by the American Society for Testing and Materials (ASTM) in ASTM F2792-12A as a process that gathers materials to form objects, from digital data from the three-dimensional (3D) model. In 2009, a technical committee was created within the ASTM designated F42 to develop fa standards according to ASTM International, F2792-12a - Standard Terminology for Additive Manufacturing Technologies. (2015).

Despite all these developments, it was only in the early 2000s that the machines of fadditive metal were created on the market, this being a method with enormous opportunities in the market. Currently the metal FA is the main focus of development of these manufacturing methods, T. Wohlers and T. Gornet, (2014)

The basic principle of this technology, originates in the creation of a 3D model using computer-aided design (CAD) software. After inserting this model into the Fabrication Aditive machine, the construction of the same is done through the creation and fusion of multiple layers of very thin section almost in two dimensions (2D), that is, material is added layer by layer, successively, until replicating the digital model 3D.P.F. Jacobs, (1993).

Figure 1 - Example of the basic principle of production by FA.



Source: Adapted from EOS e-Manufacturing Solutions (2018).

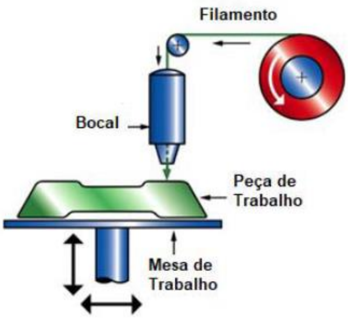
Although, in popular practice, the term "3D Printing" is used as a synonym for any of the additive f-abrication (FA) processes, there are several processes, as well as several technologies, which vary in the manufacturing method. These techniques vary depending on the material and/or technology used. In 2010, *ASTM's* F42 committee defined a set of standards and standards, which distinctly classify each of the FA processes into 7 categories according to additive manufacturing research group (2015), indicated below:

1. *VAT Photopolymerization* (VATP);
2. *Powder Bed Fusion* (PBF);
3. *Binder Jetting* (BJ);
4. *Material Jetting* (MJ);
5. *Sheet Lamination* (SL);
6. *Material Extrusion* (ME);
7. *Directed Energy Deposition* (DED).

For the manufacture of the body of the proofing device, as well as the height leveling cylinders were selected the technology called extrusion material due to its low cost, the existence of this type of printer in the laboratory and the printing facilities with FDM.

The Material Extrusion (ME) process boils down to the material being selectively deposited through a nozzle. In this process category, the part is constructed through the material that is deposited [20]. For an overview of the material extrusion process, see Figure 9. In this process, the material when passing through the nozzle, is heated and then deposited selectively. In this case, the work table is the one who makes the move, because the nozzle is fixed. After that, the work table goes down and repeats the cycle, layer by layer. The predominant technology of this process category is FDM.

Figure 2 - Schema representing FDM technology.



Adapted from Granta 2017

This uses thermoplastic filament coin, considered a plastic (artificial polymer) easily conformed and molded, which is fused during passage in the nozzle. Accuracy and speed are low when compared to other processes, however, if all parameters are well controlled, parts of some quality can be obtained. Due to the output diameter of the nozzle, for example, during the creation of a cube, it is not possible to make sharp edges (lines formed by the encounter of two surfaces of parts or elements of the construction), because there will always be a radius, however small. One of the advantages is that, as in BJ, this technology can contain one or more material feed nozzles, which allows the joining of different materials or the use of a nozzle for printing support structures and another for the production of the part as referred to in Wohlers Associates Inc. (2015).

The need to predict the behavior of materials when they are submitted to certain mechanical requests, provoked the development and use of computational methodologies. **The Finite Element Method (MEF**) is a tool or method that enables computational simulation. Suitable for several problems of analysis in various areas, from medicine to engineering, the main objective of an analysis through the MEF is to simulate the behavior of a given structure, depending on certain loads. Thus, in order to be able to obtain results close to reality, all the surrounding factors should be considered (CAMPILLO, R.D.S.G .2012)

In our view, the MEF basically consists that the geometry subjected to loading and constraints is subdivided into small parts, called elements, which become the continuous domain of the problem. Dividing geometry into small elements allows you to solve a complex problem by subdividing it into simpler problems, which enables the computer to efficiently perform these tasks. The method proposes that the infinite number of unknown variables be replaced by a limited number of well-defined behavior elements. These divisions may present different shapes, such as triangular, quadrilateral, among others, depending on the type and size of the problem. As they are elements of finite dimensions, they are called "finite elements" – a term that names the method. Finite elements are connected to each other by points, which are called nodes or nodal points. The set of all these items - elements and nodes - is called mesh. Due to these subdivisions of geometry, the mathematical equations that govern physical behaviors will not be solved exactly, but approximated by this numerical method. The accuracy of the Finite Element Method depends on the number of nodes and elements, the size, and types of mesh elements. That is, the smaller the size and the larger the number of them in a given mesh, the greater the accuracy in the analysis results.

The essence behind the MEF according to Campillo, (2012) is the use of systems of equations in matrix form, for each element given by equation (1):

$$Fe = Ke \ * Ae \qquad 1$$

Onde:
Fe - Vector of forces of an element;
Ke - Stiffness matrix of an element;
Ae - Vector of variables of an element.

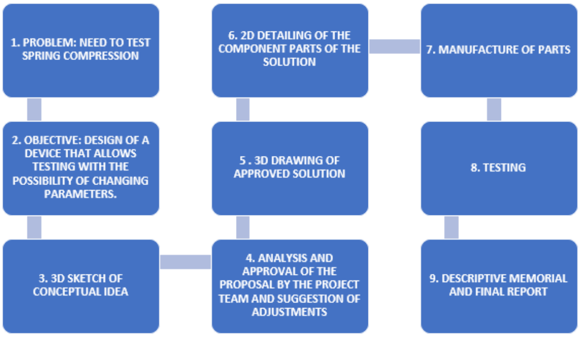
The method can be applied **in the resolution** and **diagnosis of structural** analysis problems by obtaining displacements, deformations and stresses, also allows to represent several scenarios and evaluate the performance of products with the application of criteria of resistance, stiffness or fatigue. In addition, variations of the Finite Element Method according to Giuseppe (2016) enable thermal, acoustic, dynamic, electromagnetic and fluid analysis for simpler cases of linear or other nonlinear behavior, such as when there are large displacements or contact between parts of an assembly.

Mechanical designs have a great importance in the processes of product development, and precisely in the R&D context they are keys because these allow the manufacture of the main parts and components as well as serve as the basis for simulation. The use of CAD software also allows to weigh weights and costs with a high degree of reliability, which facilitates both the reduction of working times and the costs of projects in general and thus obtaining a good cost-benefit ratio. And it is possible to affirm that the use of CAD software brings benefits in the development of mechanical projects associated with the possibility of creating libraries of drawings that facilitate the reuse of these, the simulation of the assembly allows to correct many errors before even manufacturing these parts, the ease of developing the 2D technical drawings using all the necessary views quickly, the process of quotation of the parts can be done quickly and in a well ordered way which ensures a better understanding for manufacturers, all this leads to a sharp decrease in working time, costs, thus ensuring a high quality product. (Garcia, et al, 2022)

3. MATERIALS AND METODOS

For the development of the work, the analytical structure of the project was elaborated, which allowed to obtain satisfactory results.

Figure 3. Analytical structure of the project.



Source: Authors (2022).

The steps of the analytical structure will be documented in the analysis of results and will be presented both the 3D sketches of the same and the 2D details of the component parts of the device that were obtained through the use of nx siemens software, the laptop for this development was of the type Samsung with Core i7 processor.

4. RESULTS AND ANALYSIS

4.1 Determination of the problem and objective of the research.

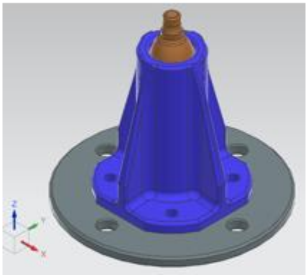
As part of the work of the project team was presented the retine of developing several tests to different springs submitted to compression recounting for this with the Universal Test Machine available at the University for these and other types of tests. When analyzing the need for tests with a high degree of repeatability as well as several springs, **the problem** arose: how to create a device that enables these tests efficiently and safely?

Derived from this problem, the objective of developing **a** device that would allow the spring to be fixed and regulate them with different levels of adjustment (compression height, quick change of springs and reliability in the fixing process is the Universal Test Machine.

4.2 Conceptual idea outline

In possession of these data the work team met and established the general ideas and starting from this was created the 3D outline of the possible solution.

Figure 4. 3D sketch of the conceptual idea of the test device.

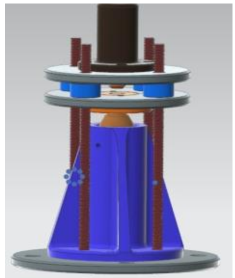


Source: Authors, 2021.

4.3 Analysis and approval of the draft proposal and suggestion of adjustments.

Once the conceptual idea is developed, the work team is meeting to evaluate and approve this idea in order to reach a functional and viable solution technically and economically. Once approved, the final draft of the proposal shall be finalized. The elements included in these adjustments include the inclusion of fixing screws, creation of holes in the base for fixing the Universal Test Machine and guide bushings of various heights for adjustment. Other elements were taken into account such as: quality of the design; construction facilities; possibility of use of 3D printing technology; Compliance with ABNT standards and other standards according to the customer's requirements, physical and mechanical requirements agree the function of the prototype; durability of the prototype and easy assembly and operation.

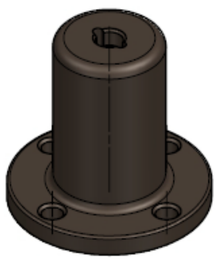
Figure 5. 3D solution sketch with adjustments.



Source: Authors, 2021.

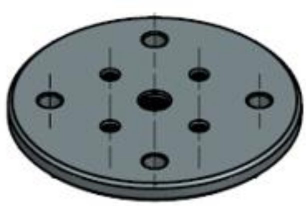
Other sketches of some parts of the device follow figures 6 and 7 below.

Figure.6 3D sketch of the larger flange tube part.



Source: Authors, 2021.

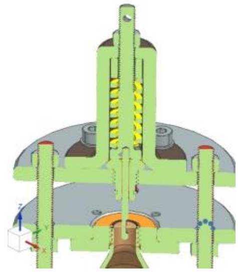
Figure 7. 3D sketch of the high base piece.



Source: Authors, 2021.

In order to represent the non-visible parts of some components, sectioned sketches were developed as shown below.

Figure 8 3D sketch of the top of the sectioned device.



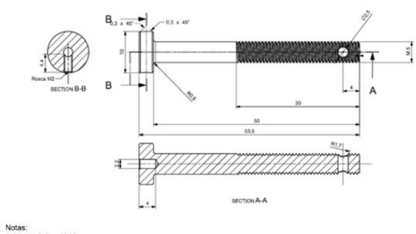
Source: Authors, 2021.

4.4 2D detailing of the component partsof the mechanical design.

Thestage is generated all the technical drawings of the parts, their dimensional specifications, adjustments and tolerances as well as the materials of each of these parts. Sometimes adjustments are needed to favor the manufacturing process.

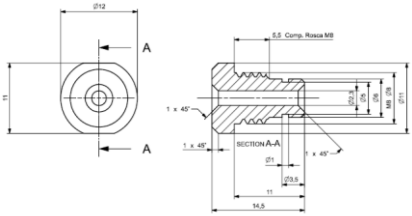
All parts and component parts of the device are detailed in the 2D CAD drawings as they appear in figures 9, 10, 11, and 12.

Figure 9. 2D drawing of the test beater piece.



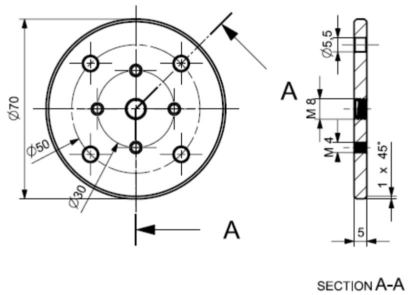
Source: Authors, 2021.

Figura 10. Desenho 2D da peça guia punção.



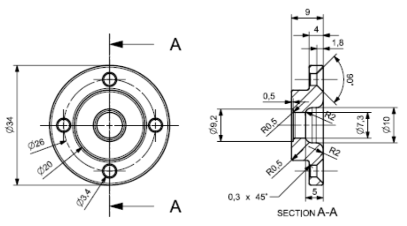
Source: Authors, 2021.

Figure 11. 2D drawing of the high base part.



Source: Authors, 2021.

Figure 12. 3D and 2D drawing of the flange cartridge part.



Source: Authors, 2021.

In these drawings one can observe with high degree of detail all the dimensional elements, shape and position of the parts such as surface roughness and dimensional tolerances as well as the description of the material to be used in manufacturing.

4.5 Manufacture of parts.

Este processo foi dividido em duas formas básicas, a manufatura supressiva tradicional para a fabricação de algumas peças de alumínio como a flange do cartucho, a base alta e os parafusos que foram fabricados em aço.

Na figura 13 embaixo é mostrado o dispositivo já construído.

Figura 13. Dispositivo construído.

Source: Authors, 2022

Parts constructed by traditional machining manufacture appear in figures 14 15 and 16.

Figure 14. High base piece made of aluminum

Source: Authors, 2021

Figura 15. Peça guia de punção fabricada em latão

Source: Authors, 2021

Figure 16. High base parts and puncture guide joined by screws

Source: Authors, 202

Another part manufactured by additive manufacture can be seen in Figure 17.

Figure 17. Device calibration rings

Source: Authors, 2021

Other height calibration parts and the main body of the device were also constructed by additive manufacturing as shown in Figure 18 below.

Figure 18. Main body of the device in the assembly process.

Source: Authors, 2021

4.6 Device testing

Once built and assembled the device was successfully used in the development of spring compression tests. For the development of the tests, the device was fixed by screwed joints the Universal Test Machine thus allowing to use this machine and proceed the planned measurements as shown in Figure 19.

Figure 19. Device being used in spring testing.

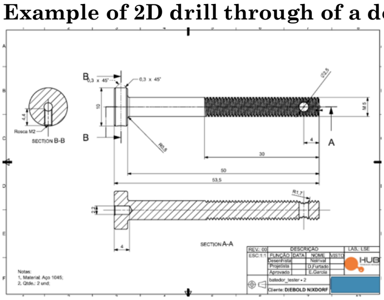
Source: Authors, 2021

4.7 Descriptive memorial and final report

The descriptive memorial of the device device consists of several documents such as drawings 3 and 2 D of all parts and component parts according to the standards established aio respect that ensure the manufacture without dimensional errors or surface roughness. A document describing the operating principle, drawings of the component parts and the safety measures to be taken during work with it.

Figure 20 below can be seen an example of this detailing, the dimensions of the part appear in the case of the beater, the general and specific dimensions appear both internal and internal as well as the type of thread, material and other information necessary for the manufacture.

Figure 20. Example of 2D drill through of a device part.



Source: Authors,2022

5 CONCLUSIONS

The application of the SIEMENS NX software enabled the development of the CAD CAM project for the manufacture of a spring testing device.

During the manufacturing process of the parts and component parts of the device two manufacturing methods were used: the classic suppressive manufacture for metal parts and the additive manufacture for the parts manufactured with PLA, which made it possible to take advantage of these and thereby save time and resources.

The results obtained in both CAD development and manufacturing validated the application of the methodology followed every time a device was obtained that worked properly in the development of spring tests.

The manufactured device may be used in future tests that require the use of mechanical parts with similar dimensional and geometric characteristics.

REFERENCES

1. Additive Manufacturing Research Group, "The 7 Categories of Additive Manufacturing."[Online]. Available:http://www.lboro.ac.uk/research/amrg/about/the7categoriesofadditivemanufacturing/ [Accessed: 15-Jul-2017].
2. ASTM International, F2792-12a - Standard Terminology for Additive Manufacturing Technologies. 2015.
3. BOURELL D. L. D, J. J. BEAMAN, M. C. Leu, and D. W. ROSEN, "A Brief History of Additive Manufacturing and the 2009 Roadmap for Additive Nanufacturing: Looking Back and Looking Ahead," US-Turkey Work. Rapid Technol., 2009.
4. CAMPILLO, R.D.S.G. Elementos Finitos. Ferramentas Para Análise Estrutural. Primeira Edição. ISBN 9897230289. 206 p. Publindústria. Brasil. 2012.
5. EOS e-Manufacturing Solutions, "Additive Manufacturing, Laser-Sintering and industrial 3D printing - Benefits and Functional Principle." [Online]. Available: https://www.eos.info/additive_manufacturing/for_technology_interested. [Accessed: 25-May-2017].
6. GARCIA Cisneros Edry Antonio; PARENTE de Oliveira Josias; Printes, André Luis; SOUZA Gomes Raimundo Claudio; CARDOSO, Fabio de Souza; DA SILVA, Navarro Pedro Emanuel; PEDRAÇA, Júnior Neirival Rodrigues; ABREU Furtado Diogo; FARIAS dos Santos Yuri; SOBREIRA, Lucio Mateus. CONSIDERAÇÕES SOBRE APLICAÇÃO DE PROJETOS MECANICOS EM PROJETOS DE PESQUISAS, DESENVOLVIMENTO E INOVAÇÃO. European Academic Research. ISSN 2286-48922.Volume IX, edição 12/março 2022.
7. GIUSEPPE M. Método dos Elementos Finitos: o que é? Blog ESSS. 2016. Disponível em: https://www.esss.co/blog/metodo-dos-elementos-finitos-o-que-e/. acesso em 5/05/2022.
8. GRANTA MATERIAL INTELIGENCE, "CES EduPack Tools and Resources," 2017. [Online]. Available: https://www.grantadesign.com/news/media.htm. [Accessed: 20-Aug-2017].

9. International Organization for Standardization (ISO) & American Society for Testing and Materials (ASTM), Additive manufacturing — General principles — Terminology (ISO/ASTM 52900:2015). 2015.
10. MEGAHED, M., MINDT, HW., N'DRI, N. et ai. Processo de fabricação de aditivos metálicos e modelagem de tensões residuais. Integr Mater Manuf Innov 5, 61–93 (2016). https://doi.org/10.1186/s40192-016-0047-2
11. QIU, Z. M. et al. Role-based 3D visualization for asynchronous PLM collaboration. Computers in Industry, v. 58, p. 747-755, 2007. doi:10.1016/j.compind.2007.02.006
12. RIBEIRO,J. Aplicação de CAD/CAE/CAM no processo de Oxicorte .https://www.academia.edu/attachments/35680402/download_file?st=MTY1MjI4Mjk2OCwxMzEuMjU1LjgzLjIyMw%3D%3D&s=swp-splash-paper-cover.Accesso em 10/05/2022.
13. Wohlers Associates Inc., "Manufacturers and Developers of Additive Systems and Materials," 2017. [Online]. Available: http://wohlersassociates.com/manufacturers-and-developers.html. [Accessed: 19-Aug-2017].