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CAD Design for Manufacturing Threadless Cylinder Device

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Abstract

In the industry in general and in the sports industry in particular, threaded cylinders of small dimensions are widely used, but there are other cylinders without thread that are much cheaper and that, in many cases, can replace the first ones, since in some of the mechanical applications they have, in their devices, threaded holes to receive CO2 cartridges. This leads to an increase in the costs of manufacturing the assembly, which can make the project economically unfeasible. On the other hand, the use of software makes it possible, in many cases, to simulate physical-mechanical and dimensional behaviors, thus reducing the manufacturing deadlines and costs. The use of CAD software also makes it possible to weigh weights and costs with a high degree of reliability, which facilitates both the reduction of development time and project costs in general, and thus the achievement of a good cost-benefit ratio. In this paper, results are presented of the application of the Siemens NX software in the development of the CAD

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CAM project for the manufacturing of a device that makes it possible to use the threadless cylinder. For the manufacturing of the device body, the additive manufacturing technology was selected due to its low cost, the existence of this type of printer in the laboratory and the FDM (Fused Deposition Modeling) printing facilities. The previous analysis of the CAD project as well as the simulation developed on the project made it possible to obtain a prototype device that allows the use of threadless cylinders in several mechanical applications, enabling both the development of the CAD project and the manufacturing of this device. Once built, the device was tested, which made it possible to validate its functionality.

Keywords: CAD, device manufacturing, testing, springs.

1. INTRODUCTION

Mechanical design is of great importance in product development processes, and precisely in the R&D field it is key because it allows the manufacturing of the parts that compose the project, as well as it serves as a basis for performing simulations to validate the project. The use of CAD software also makes it possible to weigh weights and costs with a high degree of reliability, which facilitates both the reduction of working time and project costs in general, and thus the achievement of a good cost-benefit ratio. It is possible to state that the use of CAD software brings benefits in the development of mechanical designs 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 2D technical drawings using all the necessary views quickly, the process of dimensioning of 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)

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

In this paper, the results of the application of NX Siemens software in the development of CAD CAM design for the manufacturing of a device to be used in a threadless cylinder are presented. This process was developed using additive manufacturing for the PLA fabricated parts. The results obtained enabled both the development of the CAD design and the fabrication of this device, and the tests developed validated the functionality of the device. The previous analysis of the CAD project as well as the simulation developed on the project made it possible to obtain a prototype device that allows the use of threadless cylinders in mechanical applications. For the manufacturing of the body of the device, as well as the height leveling cylinders, the additive manufacturing technology was selected due to its low cost, the existence of this type of printer in the laboratory, and the FDM printing facilities.

2. DEVELOPMENT

CAD projects that use specialized software such as Siemens NX, SolidWorks, Inventor, and others, have had an important increase in the industry due to the advantages and facilities in the development of research, investigation, and development projects, with special emphasis on the speed and economy of both time and resources, decisive elements in these works. The development of this software, in turn, is always evolving and adapting to the new manufacturing technologies that are emerging.

CAD systems, Computer-Aided Design, is the generic name for computer systems used by engineering, geology, architecture, and industrial design to execute projects and technical drawings (NAVEIRO, 2010).

Since the 1980s, three elements have revolutionized the treatment of design in industry: CAD, CAD and CAM. With the application of these tools, manual sketching and calculation tasks are practically eliminated, so that many designers and manufacturers when developing new products make fewer errors in the design of parts and components, in the selection of materials and in the configurations of manufacturing tools (Richardson and Lokensgard, 2000).

CAE (Computer-Aided Engineering) is a generic term denoting the use of computer resources in essential product engineering tasks. CAM (Computer-Aided Manufacturing) is related to the control of product manufacturing processes. CAI - Computer-Aided Inspection, is software that checks if the geometry machined in CNC machines is consistent with the model generated in CAD. (CAROZZI, 2009)

In design, the use of data processing and information technology serves both to improve the product and to reduce the cost of design and production (PAHL; BEITZ,1996; PAHL et al., 2005). Thus, these authors define CAD as the technique of project work linked to the use of the computer through the use of peripherals and appropriate programs.

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

As defined by Tut et al. (2010), CAD is the use of computers as technology for the design of real or virtual objects, and that can also be divided into two forms of application: to draw curves and figures in two-dimensional space ("2D"); or curves, surfaces or solids in three-dimensional objects ("3D").

According to Bernardes et al. (2012): "The CAM process, or computer-aided manufacturing, is the process of materialization or manufacturing of the virtual image worked in CAD software, which allows quality control at the micrometric level, being of great importance, especially in infrastructure."

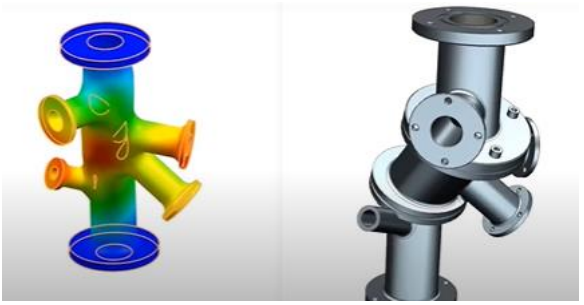
For Do Carmo (2017), with feature-based modelers, the design cycle can be reduced, automating the detailing process.

With all the advances in CAD techniques, software packages aimed at computational mechanics have become frequent, enabling the user to perform not only the design (graphic representation of the project), but also simulations from generated models.

Among the software packages mentioned are NX Siemens, SolidWorks, Autocad, and Inventor, among others. All with many advantages and few disadvantages when it comes to CAD CAM CAE processes.

The software NX Siemens is nowadays one of the most used in the industry and specifically in the industrial hub of Manaus, it has great applicability, it has many tools and provides solutions for CAE, product design, 3D printing, mechanical design in general as well as machining and validation.

Figure 1. Siemens NX Applications



Fonte: Siemens Ingenity for life.2018

The use of 3D CAD software for the design of mechanical related parts can allow designers to design with more clarity and detail. The machine model built with this software is a three-dimensional model. This is also the main reason why this technology is widely used in modeling mechanical construction schemes. In addition, 3D CAD software mainly uses frame technology, 3D technology and surface technology to model the machine structure, and the software also contains many graphics related to mechanical structure.(XIANGFENG, L .2018)

Optimizing the structural design, analyzing the design plans and comparing the plan data are the main functions of mechanical CAE software. A reasonable and scientific mechanical design plan is formed through these three points and evaluated. Only in this way can the standardization of the mechanical design scheme be guaranteed. First, the relevant personnel must do a good job in building the corresponding model, and then the mechanical CAE software is responsible for the design and analysis to ensure the implementation of the mechanical design plan. This is the whole process of applying 3D CAD technology to mechanical CAE software. (Chulu, X. 2019).

The finite element method (FEM) basically consists of subdividing the geometry subjected to loads and constraints into small parts, called finite elements, which then come to represent the continuous domain of the problem. The division of the geometry into small elements allows a complex problem to be solved by subdividing it into simpler problems, which enables the computer to perform calculations more efficiently. The method proposes that the infinite number of unknown variables be replaced by a limited number of elements of well-defined behavior. These divisions can present different shapes, such as triangular, quadrilateral, among others, depending on

the type and dimension of the problem. As they are finite dimensional elements, they are called "finite elements" - the term that names the method. The finite elements are connected to each other by points, which are called nodes or nodal points. The set of all these elements - elements and nodes - is called a mesh. Due to these subdivisions of the geometry, the mathematical equations that govern the physical behavior will not be solved exactly, but approximately by this numerical method. The accuracy of the Finite Element Method depends on the number of nodes and elements, the size and the types of mesh elements. That is, the smaller the size and the greater the number of them in a given mesh, the greater the accuracy in the analysis results (CISNEROS E.A.G. ET ALL, 2022)

The finite element method (FEM) analysis is used worldwide for several applications due to the accuracy of the results and the possibilities of virtual simulation in several scenarios, elements that favor the reduction of resources and costs.

One of the foundations of Industry 4.0 is to adopt additive manufacturing, such as 3D printing to produce small batches of products that will allow in some cases to reduce transportation distances and the cost of holding inventory through the decentralization of production, that is, seeking to obtain several additive manufacturing centers (HeinerLasi; et al, 2014).

García et al (2022) mention that in mechanical projects the use of CAD technologies is a premise of work because it allows obtaining solutions with a high degree of accuracy, as well as a level of detailing that facilitates later the process of construction of the component parts, as well as the modeling of the solutions. Very often these projects lead to the development of new products in industries.

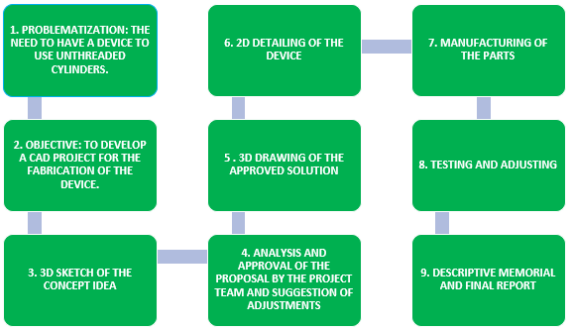
In summary, it can be concluded that the concepts associated with Industry 4.0 promote a revolution in the production system through technological resources. The evolution of these systems may allow to aggregate the functions of planning, development, modeling, design and maintenance in a highly dynamic and versatile information system that will take companies to another level of competitiveness (HeinerLasi; et al, 2014).

3. MATERIALS AND METHODS

This topic will cover all the methodological aspects of the research conducted, describing the procedures needed to manufacture the device by 3D printing. The purpose of this study was to carry out research of applied nature. To reach the proposed objectives and better appreciate this work, a qualitative-quantitative approach was used. In order to get to know the problematic about the study area, exploratory research was carried out. To obtain the necessary data, the following technical procedures were used: bibliographical research and case study. For the development of the work, the analytical structure of the project was elaborated, as shown in figure 2.

To obtain the CAD design and its final manufacturing ready for its use in the 3D printing process the steps described in Figure 2 were followed. Each step will be detailed in the results described below. This detailing will be accompanied by the CAD drawings obtained during the development of the work. The software used was the Siemens NX installed on a Samsung Core i7 laptop.

Figure 2: Project analytical framework



Source: Authors, 2022

In this specific case, the problem is the following: How to create a device produced specifically to take advantage of the existing threadless cylinders on the market in various industrial applications?

Objective

Derived from this problem, the objective is to develop a CAD project to manufacture a threadless cylinder device efficiently and safely.

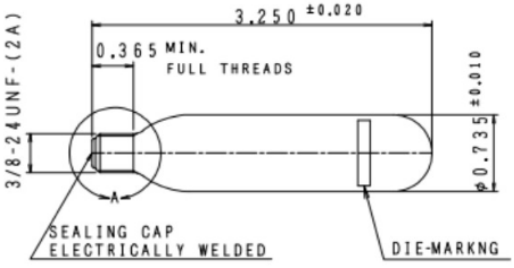
Sketch of the conceptual idea

It is about the need to build a device that allows the use of threadless cylinders existing in the market for use in applications where it must be fixed and ensure that once pierced by some procedure guarantees the gas leakage in the proper proportions without leakage and with safety and efficiency.

Considering then the objective of the work, the team determined the general ideas and from this was created the 3D sketch of the possible solution. The following were taken into consideration: a) the possibility of using the threadless cylinder; b) its geometrical and dimensional data. See figure 3; c) the need to guarantee hermeticity during its use once the cylinder is drilled; d) guarantee assembly facilities.

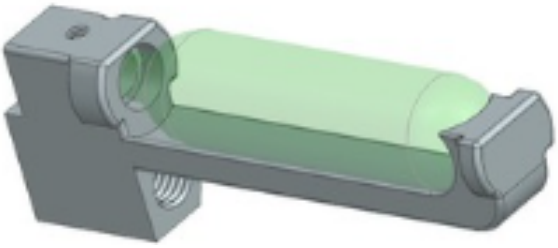
In possession of these data the 3D sketch of the solution was developed. See figure 4

Figure 3. Dimensional and geometrical data of the threadless cylinder



Source: Leland, 2021.

Figure 4: 3D sketch of the solution



Source: Authors, 2022.

Analysis and approval of the solution

Once the solution was developed, the work team approved the proposed solution since it meets the specifications established as requirements.

It was important to consider the material to be used for its manufacture: using additive manufacturing, in this case 3D printing with a filament printer, it was determined to use a polymeric material that guarantees the hermeticity and at the same time facilitates the process of assembling the cylinder. Some adaptations were also determined in order to achieve the proposed objectives.

The additive manufacturing process involves the material being selectively deposited through a nozzle. In this process category, the part is constructed by depositing the material, as opposed to conventional manufacturing processes where the material is extracted from a raw body. The predominant technology of this process category is FDM (Fused Deposition Modeling).

The main adaptations suggested were:

- Increasing the length of the top of the device to make it easier to fit the working pipes.

- Increase the chamfer on the other part of the device to facilitate the alignment of the cylinder during assembly.

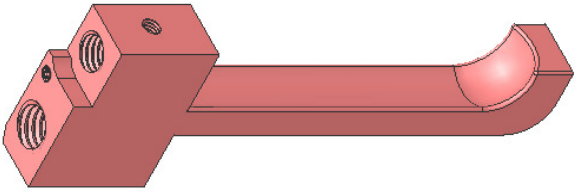
- Use structural reinforcements in some parts to ensure its strength.

3D sketch of the solution approved by the work team.

Once the solution was approved, a 3D sketch of the final solution was developed, as shown in figure 5.

Some adaptations were incorporated into this solution to facilitate both the assembly and its efficient operation. The finishing on the right side where the cylinder will be fixed, the reinforcement of this part during the 3D printing, as well as the reinforcement of the part of the body that is underneath the cylinder to ensure its tightness.

Figure 5. 3D sketch of the final prototype solution.



Source: Authors, 2022.

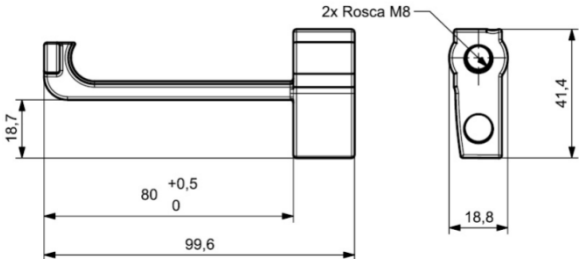
2D Detailing of the device.

In this step all the technical drawings of the parts, their dimensional specifications, fits and tolerances as well as the materials of each of these parts are generated. Sometimes it is necessary to make adjustments to facilitate the manufacturing process.

All parts and component parts of the device are detailed in 2D CAD drawings.

In figure 6 below you can see the form and position dimensions, fits and tolerances as well as the main elements needed for printing such as holes, thread types, quantities, etc.

Figure 6: Example of 2D detailing of the device.



Source: Authors, 2022.

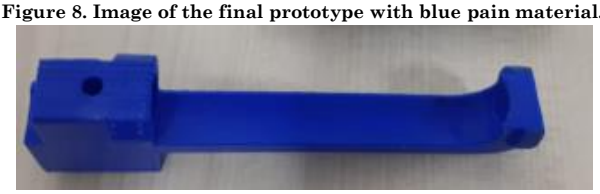
Manufacture of the part

With the data from the 3D sketch and the 2-D drawings (detailing of the device) we proceeded to manufacture the device. This process was developed by the additive manufacturing method, in this case 3D printing with PLA material.

Figure 7. Images of the first prototypes manufactured by the 3D printing method

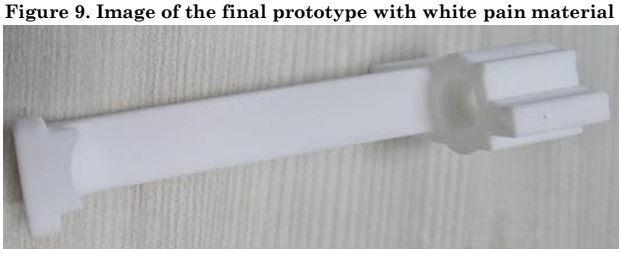
Source: Authors, 2022.

Figure 8. Image of the final prototype with blue pain material.



Source: Authors, 2022

Figure 9. Image of the final prototype with white pain material

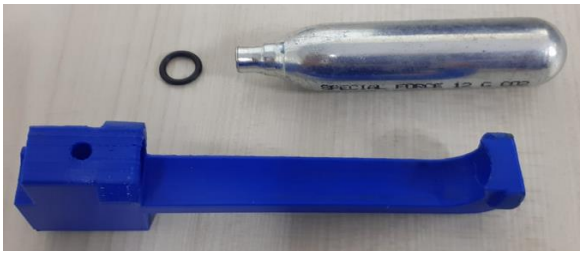


Source: Authors, 2022

Tests and adjustments

Once the device was built and assembled, it was used successfully in the development of drive tests on the device. For the development of the tests, the cylinder was mounted on the device several times to test the mounting facilities. Altogether, 90 different cylinders were mounted in the device and 100 % of the time the assembly was successful. These tests were conceptual in order to obtain a criterion of effectiveness regarding hermeticity and also practicality in the assembly process. Future tests will be developed to statistically evaluate the results with more assertive criteria. Figure 10 shows the arrangement of the device's integral parts.

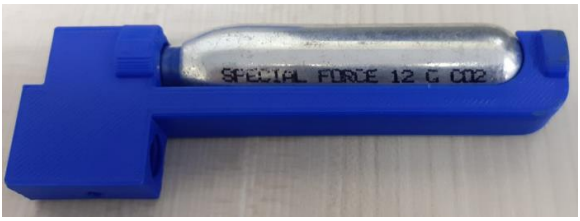
Figure 10. Image of the initial arrangement of the integral parts of the device ready for assembly.



Source: Authors, 2022

Como se observa somente e necessário um anel de vedação e com isso é suficiente para garantir a hermeticidade. Na figura 11 embaixo é mostrado o dispositivo pronto e montado com o cilindro sem rosca.

Figura 11. Cilindro sem rosca montado no dispositivo.

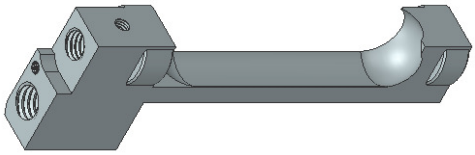


Source: Authors, 2022

Descriptive Memorandum

The descriptive memorial of the device for mounting the threadless cylinder is made up of several documents such as drawings 3 and 2 D of all the component parts and pieces according to the standards established in respect that guarantee manufacturing without dimensional or surface roughness errors. A document describing the operating principle, drawings of the component parts and the safety measures that must be taken while working with it. Figure 12 shows the final sketch of the solution already with the modifications

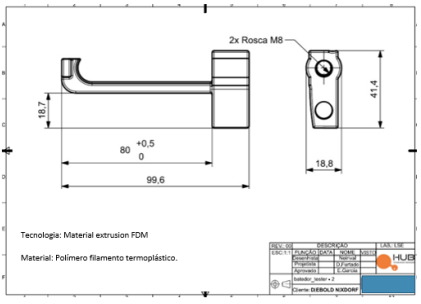
Figure 12. 3D sketch of the solution



Source: Authors, 2022

In figure 13 below you can see an example of this detailing, the dimensions of the part, in this case the developed device, appear, the general and specific dimensions, both internal and internal, as well as the type of thread, material and other information necessary for manufacturing.

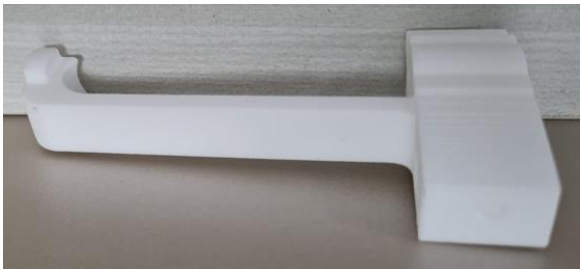
Figure 13. 2D Detail



Source: Authors, 2022

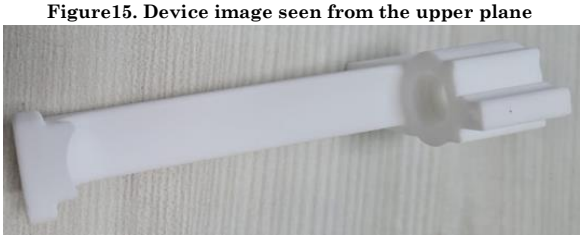
It is also customary to add images of the device already built according to the 2D detailing in this memorial. in this case images of the device built by 3D printing are presented. Figures 14,15 and 16 show images of the manufactured device.

Figure 14. Side view image of the built device



Source: Authors, 2022

Figure15. Device image seen from the upper plane



Source: Authors, 2022

Figure16. Image of the right side of the device as seen from the top plane.

Source: Authors, 2022

5. CONCLUSIONS

The results obtained allowed both the development of the CAD project and the fabrication of this device and the tests developed validated the functionality of the device.

The previous analysis of the CAD project as well as the simulation developed on the project made it possible to obtain a prototype device that allows the use of threadless cylinders in mechanical applications.

To manufacture the body of the device, as well as the height leveling cylinders, the additive manufacturing technology was selected due to its low cost, the existence of this type of printer in the laboratory and the FDM printing facilities, and the results obtained were favorable.

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Most relevant publications:

1. CISNEROS Edry Antonio Garcia. Rational Structure of the System of Machines in the Transport Process Rice Harvest. International Journal of Research in Engineering &Technology., Vol 6, page 9 - 19, 2019.
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PhD from the Federal University of Pará - UFPA, with a thesis on Smart Grids models applied to low voltage distribution networks, having carried out a one-year sandwich internship at the Polytechnic of USP (2015 - 2016). He obtained a master's degree in 2002 from the Federal University of Campina Grande in Paraíba - UFCG/UFPB, and graduated in electrical engineering from the Institute of Technology of the Amazon - UTAM, since 1991. Professor at the Superior School of Technology of the State University of Amazonas EST/ UEA since October 2001, however, joining the effective

staff of this university only from January 2008 (via competition). At this School, he has regularly taught the subjects Energy Efficiency, Renewable Energies, Smart Grids and Analog Electronics I, from the undergraduate courses in electrical, electronics and computer engineering. He is the leader of the Research Group of the Core of Cyber-Physical Systems and coordinates the Laboratory of Embedded Systems (LSE), replacement of the former NSE, in the R, D & I center called HUB Tecnologia e Inovação. In the team at the Embedded Systems Nucleus (NSE), which he helped create in 2006, he developed R&D work for companies in the electricity sector, such as El Paso and GrupoEletrobras (Manaus Energia and CEPISA) with research in the areas of Smart Grid: electronic control systems in electricity distribution networks, smooth switching system for low voltage circuits for dynamic balancing of single-phase loads in three-phase electrical systems, development of real-time monitoring systems for distribution transformers and of low voltage networks. He directly assisted in the design, proposal, coordination and implementation of the Technology and Innovation Development Center (CDTI), for structuring applied research laboratories at UEA; as well as, he served in the deputy directorship of the Agency of Technological Innovation of the UEA, contributing for its implantation and consolidation. In March 2014, he left teaching for a doctorate at UFPA and, through a sandwich internship, developed part of his research at the Polytechnic School of USP in the Design and Modeling in Engineering Systems laboratory. On account of almost thirty years working in the technological area, he has accumulated experience of almost 18 years in the study of automation solutions applied in electric energy distribution systems (including Smart Grids); twelve years in the field of information technology (Teleprocessing and Data Communications), three years in product engineering and industrial production, two years in coordinating research teams, having also carried out work on distributed systems (master's research) with application in systems to inhibit theft, employing biometric linking between an individual and the collection of all their technological goods equipped with electronic control and processing resources. Currently, in the coordination of the LSE/HUB, he has participated in the execution of RD&I projects for companies in the Industrial Pole of Manaus (PIM), among which I cite: DIebold, TPV/Envision, Salcomp and SAGEMCOM

Most relevant publications:

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Most relevant publications:

1. Participant as co-author of the chapter: Analysis of Energy Quality and Efficiency Based on Harmonic Indexes in Electrical Systems. CARDOSO, F.S.; TORNE, I.G.; SILVA, H.L.N.; FERNANDES, R. A.; SILVA, S. S. S. Electrical engineering: the path to sustainable development. 1st ed. Campina Grande - PB: EditoraAmplla, 2021, v.1, p. 84-96.
2. Participant as co-author of the chapter: Evaluation Methodology of "Open Source" ERP Systems for Medium and Small Companies. SILVA, V.R.; CARDOSO, F.S.; LIMA, E.E.; LIMA, R. M. Production engineering: foundation of competitiveness. 164-183.
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PhD in Electrical Engineering from the Federal University of Ceará UFC (Revalidation 2019).PhD in Technical Sciences, in the field of Electrical Engineering from the University of Camaguey (2015). Master's Degree in Electrical Engineering (1998) and Graduation in Electrical Engineering (1995) from the University of Camaguey and recognized by the University of the State of Amazonas (2018). He is currently an Adjunct Professor, Coordinator and President of the Structuring Teaching Nucleus of the Electrical Engineering Course at the Superior School of Technology at the State University of Amazonas. He has experience in the field of Electrical Engineering, with

an emphasis on Electrical Power Systems and Energy Efficiency. He develops the lines of research: Energy Efficiency; Maintenance of electrical substations and Operation of Electrical Power Systems. Advisor of several Final Papers, Course Projects and Master's Degrees, participated in national and international events, published several articles on maintenance in power circuit breakers. Visiting professor at several universities in different countries such as Ethiopia, Venezuela, Ecuador and Mexico; taught different disciplines in undergraduate and graduate courses in the Master's in Electrical Engineering and Master's in Energy Efficiency programs, registered two software related to circuit breaker maintenance and failure calculation. He currently belongs to the Embedded Systems Development Team (ESDT) Research Group, Embedded Systems Laboratory of the HUB-Technology and Innovation, at the State University of Amazonas, Brazil.

Most relevant publications:

1. Author of the paper: Modelo de gestión de mantenimiento parcial a interruptores de potencia mediante inteligencia artificial. GONDRES T., I.; LAJES CHOY, S.; DEL CASTILLO S., A. Revista Chilena de Ingeniería, v. 26, p. 391-397, 2018.
2. Author of the chapter: Model Business Rules for Control Load through Electrical Parameters. TORNÉ, I. G.; TEIXEIRA, R. C. M.; MESTRINHO, G. S. P.; DA COSTA, I. V. B.; DE ALMEIDA, A. S.; DOS SANTOS C., EVALDO P., Smart Innovation, Systems and Technologies. 1ed.: Springer International Publishing, v. 1, p. 249-257. 2021.
3. Participant as co-author of the chapter: Automatic Balancing System of Single-Phase Consumer Units Connected to the Low-Voltage Distribution Network. DIAS, ALEX SANDER LEOCÁDIO; TORNÉ, ISRAEL GONDRES. Smart Innovation, Systems and Technologies. 1ed.Switzerland: Springer International Publishing, v., p. 97-111. 2021.

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Most relevant publications:

1. Author of the paper: Beamformingdistribuídobaseadoeminversãoremota de fase: Uma prova de conceitoem GNU-Radio/USRP / Distributed Beamforming based on Remote Phase Inversion: A GNU-Radio/USRP Proof of Concept. SOBRINHO, ANGILBERTO; GURJÃO, EDMAR ; NETO, J. XXXVIII Simpósio Brasileiro de Telecomunicações e Processamento de Sinais, 2020. Anais de XXXVIII Simpósio Brasileiro de Telecomunicações e Processamento de Sinais, 2020.
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Most relevant publications:

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Most relevant publications:

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Graduating in Mechanical Engineering at the State University of Amazonas (UEA-EST). I worked as a Mechanical Designer at Ribro Group where I participated in the elaboration of several engineering solutions in the metal-mechanical segment, I was an intern in the Product Engineering sector at Midea Carrier companies in the refrigeration segment and at Yamaha Motor in the motorcycle segment. Currently I work as a designer and researcher in RD&I projects (Research, Development and Innovation) in agreement with UEA and PIM companies (Manaus Industrial Pole);
Most relevant publications:

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Most relevant publications:

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Most relevant publications:

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