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Modeling the design of mechanical parts

‹‹ Rotary alternator cooling blades ››

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Summary

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List of Abbreviations

CAD : Computer-Aided Design

RPM : Revolutions Per Minute

DC : Direct Current

FOD : Foreign Object Debris

CFD : Computational Fluid Dynamics

FEA : Finite Element Analysis

GD&T : Geometric Dimensioning and Tolerancing

STEP : Standard for the Exchange of Product

IGES : Initial Graphics Exchange Specification

MEI : The Industrial Equipment Maintenance Company

General Introduction

General introduction :

Mechanical engineering involves designing and developing mechanical parts, devices, and systems that are essential for modern society. One important aspect of mechanical engineering is modeling the design of mechanical parts, which involves using advanced software tools and simulation techniques to create virtual models of parts and test them under various conditions.

Modeling the design of mechanical parts is an important aspect of the product development process. It allows engineers to visualize and evaluate different design concepts before building a physical prototype. This can save time and reduce costs, as well as help identify potential problems early in the design phase.

This thesis will explore the use of modeling in the design of rotary generator cooling blades. Rotary generators are used in a variety of applications, including wind turbines, electric vehicles, and power plants. The cooling blades in these generators are responsible for removing heat from the generator's rotor.

The thesis will be divided into three chapters. The first chapter will explore the design of rotary generator cooling blades. The second chapter will discuss modeling and reverse engineering for mechanical design. The third chapter will present the design modeling process for a cooling blade.

Chapter I

Exploring Rotary Generator Cooling Blades

I.1. Introduction:

In this chapter, we will delve into the design, function, and manufacturing of rotary generator cooling blades. Cooling blades play a vital role in the overall cooling system of an alternator, as they are responsible for efficiently dissipating the heat generated by the alternator's rotor. By understanding the different types of cooling blades and their advantages and disadvantages, we can gain valuable insights into optimizing the cooling system for enhanced performance and reliability.

I.2. Definition of rotary generator cooling blades:

Rotary alternator cooling blades are a critical component of high-speed generators used in power generation systems. These blades play a crucial role in maintaining the temperature of the generator within safe operating limits, preventing damage to the generator and ensuring reliable and efficient operation.

The purpose of cooling blades is to dissipate the heat generated by the generator during operation. This is particularly important in high-speed generators, where the rotational speed of the rotor can generate significant amounts of heat [1]. If the temperature of the generator exceeds safe operating limits, it can lead to reduced efficiency, damage to the generator, and even complete failure.

Rotary alternator cooling blades typically consist of a series of small, curved blades that are attached to the rotor shaft. These blades are designed to direct cooling air or gas over the surface of the rotor, where it absorbs heat and carries it away from the generator [2]. The design of the cooling blades is critical to their effectiveness, as they must be able to direct the cooling airflow precisely where it is needed to ensure maximum cooling efficiency.

The cooling blades are typically made of high-strength materials such as aluminum or titanium, which can withstand the high stresses and temperatures generated during operation. They must also be designed to minimize air resistance and turbulence, as this can reduce the efficiency of the generator and increase wear and tear on the blades.

One of the key challenges associated with designing and manufacturing rotary alternator cooling blades is ensuring that they are precisely balanced. Any imbalance in the blades can lead to vibration, which can cause damage to the generator and reduce its efficiency [3]. To prevent this, the blades must be carefully machined and balanced to ensure that they rotate smoothly and evenly.

Figure I.1 : Rotary generator cooling blade and its installation location.

In summary, rotary alternator cooling blades are a critical component of high-speed generators used in power generation systems. They play a crucial role in maintaining the temperature of the generator within safe operating limits, preventing damage and ensuring reliable and efficient operation. The design and manufacture of these blades are critical to their effectiveness, and require careful attention to detail and precision engineering to ensure that they operate smoothly and efficiently.

I.3. The design of rotary generator cooling blades :

The design of rotary generator cooling blades is a critical aspect of the development and operation of high-speed generators used in power generation systems. The design of these blades must take into account a range of factors, including the operating conditions of the generator, the materials used in their construction, and the aerodynamic performance of the blade itself.

One of the key considerations in the design of rotary generator cooling blades is the operating temperature of the generator. These blades must be able to dissipate heat effectively, preventing the temperature from exceeding safe operating limits and ensuring that the generator operates efficiently and reliably [4]. The design of the blades will need to take into account the thermal properties of the materials used in their construction, as well as the airflow and cooling systems used to maintain the temperature within safe limits.

Another important consideration is the aerodynamic performance of the blade. Cooling blades must be designed to minimize air resistance and turbulence, which can reduce the efficiency of the generator and increase wear and tear on the blades [4]. The design of the blade will need to take into account the speed and airflow patterns around the rotor, as well as the geometry and curvature of the blade itself.

Figure I.2 : Different types of cooling blade design.

In addition to these factors, the design of rotary generator cooling blades must also take into account the materials used in their construction. These blades are typically made of high-strength materials such as aluminum or titanium, which can withstand the high stresses and temperatures generated during operation [5]. The design of the blade must be optimized to maximize the strength and durability of the material while minimizing weight and cost.

To design rotary generator cooling blades, engineers typically use computer-aided design (CAD) software to create 3D models of the blade. These models can be used to simulate the behavior of the blade under different operating conditions, allowing engineers to optimize the design for maximum performance and efficiency [5]. Once the design is finalized, the blades can be manufactured using precision machining techniques and assembled onto the rotor shaft using specialized tools and techniques.

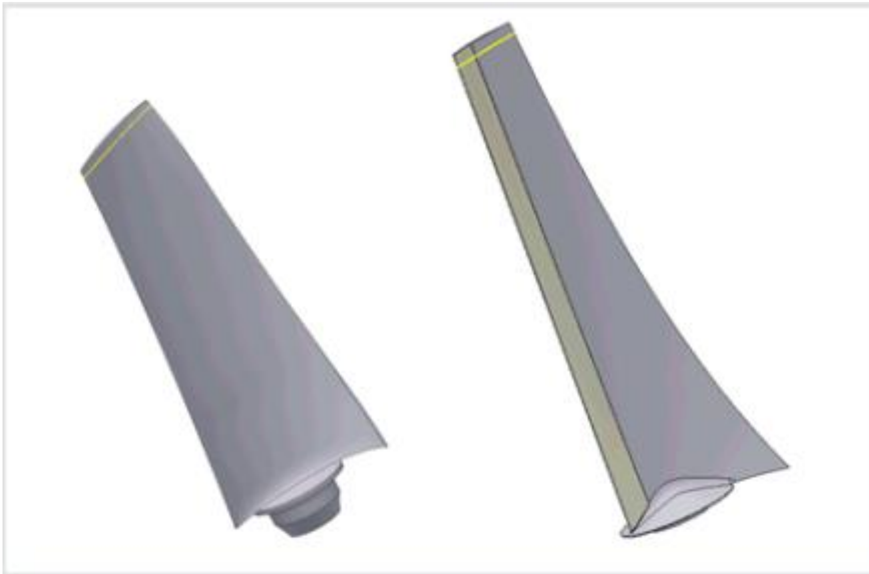


Figure I.3 : Cooling blade design using CAD software.

In summary, the design of rotary generator cooling blades is a critical aspect of the development and operation of high-speed generators used in power generation systems. The design must take into account a range of factors, including the operating conditions of the generator, the materials used in their construction, and the aerodynamic performance of the blade itself. Computer-aided design software is typically used to optimize the design for maximum performance and efficiency, and the blades are manufactured using precision machining techniques and assembled onto the rotor shaft using specialized tools and techniques.

I.4. The function of rotary generator cooling blades :

The function of rotary generator cooling blades is to remove heat from the generator's stator windings. The stator windings are the stationary coils of wire that create the magnetic field that rotates the generator's rotor [1]. As the stator windings carry current, they generate heat. If this heat is not removed, the stator windings can overheat and fail.

Rotary generator cooling blades work by circulating air over the stator windings. The air is drawn in by the blades and blown over the windings. As the air flows over the windings, it carries away the heat. The heat is then dissipated to the surrounding air.

Rotary generator cooling blades are an essential part of any rotary generator. Without them, the stator windings would overheat and fail.

Here are some of the benefits of using rotary generator cooling blades:

Increased efficiency : Rotary generator cooling blades can help to improve the efficiency of a generator by removing heat from the stator windings [2]. This can lead to lower operating costs and a longer lifespan for the generator.

Reduced noise : Rotary generator cooling blades can help to reduce the noise produced by a generator. This is because the blades help to circulate air over the stator windings, which helps to dissipate heat and reduce friction.

Improved reliability : Rotary generator cooling blades can help to improve the reliability of a generator by preventing the stator windings from overheating and failing. This can lead to fewer unplanned outages and a lower risk of downtime.

Extended generator life : Rotary generator cooling blades can help to extend the life of the generator by preventing it from overheating [3]. Overheating can cause the generator's components to wear out prematurely, leading to costly repairs or even replacement.

Reduced maintenance costs : Rotary generator cooling blades can help to reduce maintenance costs by preventing the generator from overheating. When the generator is not overheating, it is less likely to experience problems such as overheating, which can lead to costly repairs or even replacement.

Overall, rotary generator cooling blades are an important part of the generator's cooling system. They can help to increase generator efficiency, extend generator life, and reduce maintenance costs.

I.5. Manufacture of rotary generator cooling blade :

The manufacture of rotary generator cooling blades is a complex process that requires specialized knowledge and expertise in materials science, machining, and engineering. The design and manufacture of these blades are critical to ensuring the reliability, efficiency, and safety of high-speed generators used in power generation systems.

The manufacturing process typically begins with the selection of high-strength materials such as aluminum or titanium, which can withstand the high stresses and temperatures generated during operation [2]. The chosen material is then cut and shaped into the desired size and shape using precision machining techniques such as milling, turning, and drilling.

Next, the blade is carefully balanced to ensure that it rotates smoothly and evenly, without causing any vibrations that could damage the generator or reduce its efficiency. This is typically done using specialized equipment such as dynamic balancing machines, which can detect even small imbalances in the blade and correct them.

After balancing, the blade is typically subjected to a series of heat treatments and surface treatments to improve its strength, durability, and resistance to corrosion. These treatments may include annealing, quenching, tempering, and surface coatings such as anodizing or electroplating.

Once the blade is fully machined and treated, it is assembled onto the rotor shaft using specialized tools and techniques. Care must be taken during assembly to ensure that the blade is properly aligned and securely fastened to the rotor shaft, as any misalignment or looseness can cause damage to the generator or reduce its efficiency [2] .

Finally, the completed rotor assembly is subjected to a series of rigorous quality control tests to ensure that it meets the required specifications for performance, safety, and reliability. These tests may include dynamic balancing, vibration testing, thermal imaging, and other specialized techniques to detect any defects or issues that could affect the performance of the generator.

In conclusion, the manufacture of rotary generator cooling blades is a complex and specialized process that requires expertise in materials science, machining, and engineering. The design and manufacture of these blades are critical to ensuring the reliability, efficiency, and safety of high-speed generators used in power generation systems, and require careful attention to detail and precision engineering to ensure that they operate smoothly and efficiently.

I.6. Definition of rotary generator :

Rotary generators are critical components of modern power generation systems, providing a reliable and efficient way to convert mechanical energy into electrical energy. These generators are used in a wide range of applications, from small portable generators to large-scale power plants that generate hundreds of megawatts of electricity. One such generator is the 110MW rotary generator, which is used in medium-sized power plants to generate electricity for residential and commercial use.

The 110MW rotary generator is a synchronous generator, meaning that it operates at a fixed speed and is synchronized with the frequency of the power grid. It is designed to operate at a high level of efficiency, converting the mechanical energy generated by a turbine into electrical energy with minimal losses. The generator typically operates at a speed of 3,000 to 3,600 revolutions per minute (RPM), and is designed to operate continuously for long periods of time.

Figure I.4 : Rotary generator 110MW.

The 110MW rotary generator consists of several key components, including the stator, rotor, and exciter. The stator is the stationary part of the generator, and consists of a core made of laminated steel sheets that are stacked together to reduce losses due to eddy currents. The stator core is wound with copper wire, which generates a magnetic field when an electrical current is passed through it. This magnetic field interacts with the magnetic field of the rotor, which is the rotating part of the generator.

The rotor is typically made of a high-strength magnetic material, such as laminated steel or iron, and is wound with copper wire to create a magnetic field. The rotor rotates within the stator, generating a voltage in the stator windings as it moves [6]. The exciter is a small generator that is used to provide a source of direct current (DC) to the rotor windings, which creates the magnetic field in the rotor.

The 110MW rotary generator is a complex machine that requires careful design and maintenance to ensure reliable and efficient operation. The generator must be designed to withstand the high forces and temperatures generated during operation, and must be able to operate continuously for long periods of time without interruption. To achieve this, the generator is typically cooled with air or water, and is equipped with a variety of sensors and monitoring systems to detect and respond to any issues that arise.

In summary, the 110MW rotary generator is a critical component of modern power generation systems, providing a reliable and efficient way to convert mechanical energy into electrical energy. Its complex design and high level of performance make it an essential component of medium-sized power plants, ensuring that electricity is generated efficiently and reliably to meet the needs of residential and commercial users.

I.7. Maintenance Practices for Rotary Generator Cooling Blades:

Rotary generator cooling blades play a critical role in maintaining the efficient and reliable operation of high-speed generators used in power generation systems. To ensure their optimal performance, regular maintenance and inspection of these cooling blades are essential. This article delves into the key aspects of rotary generator cooling blades maintenance, highlighting the importance of proper maintenance practices in maximizing cooling efficiency, extending blade lifespan, and preventing potential issues that could lead to system failures.

I.7.1. Regular Inspection:

Regular inspection is a fundamental component of rotary generator cooling blades maintenance. Visual inspections should be conducted to identify any signs of erosion, wear, damage, or foreign object debris (FOD) accumulation on the blade surfaces. Inspections should also encompass the attachment points of the blades to the rotor shaft to ensure secure fastening and alignment [3]. Any irregularities or anomalies detected during inspections should be promptly addressed to prevent further deterioration.

I.7.2. Blade Cleaning:

Cleaning the cooling blades is crucial to maintain their optimal performance. Over time, the blades may accumulate dust, dirt, or contaminants, hindering proper airflow and heat dissipation. Cleaning methods may vary based on the specific requirements and materials used in the blades. Care should be taken to use appropriate cleaning agents and techniques to avoid damage to the blade surfaces or coatings. Regular cleaning helps maintain the efficiency of the cooling system and prevents potential overheating issues.

I.7.3. Blade Balancing:

Proper blade balancing is essential for the smooth operation of the rotary generator. Imbalances in the cooling blades can lead to vibrations, increased wear, and reduced system efficiency. Dynamic balancing techniques should be employed to identify any imbalances and subsequently correct them [3]. This process ensures that the blades rotate evenly, minimizing stress on the blades, rotor, and generator components.

I.7.4. Lubrication:

Lubrication of the cooling blades' attachment points is vital to reduce friction and wear. Lubricants specifically designed for high-speed rotating components should be applied at the interfaces between the blades and the rotor shaft. Proper lubrication helps mitigate potential damage caused by excessive friction, ensuring smooth rotation and extending the lifespan of the blades.

I.7.5. Corrosion Protection:

Rotary generator cooling blades are exposed to various environmental conditions, which may include humidity, moisture, and corrosive elements. Implementing corrosion protection measures is crucial to prevent degradation of the blades' surfaces and structural integrity. This can involve the application of corrosion-resistant coatings, periodic inspections for signs of corrosion, and prompt remedial actions to address any identified corrosion issues.

I.7.6 Blade Replacement:

Over time, cooling blades may reach the end of their lifespan or experience irreparable damage. In such cases, timely blade replacement is necessary to maintain the cooling system's performance and prevent potential failures. Replacement blades should be manufactured to the required specifications, considering factors such as material strength, heat transfer efficiency, and aerodynamic characteristics. Proper installation and alignment procedures should be followed during the replacement process to ensure optimal performance and longevity.

The maintenance of rotary generator cooling blades is a critical aspect of ensuring the optimal performance and reliability of high-speed generators used in power generation systems. Regular inspection, cleaning, balancing, lubrication, corrosion protection, and timely blade replacement are essential maintenance practices [3]. By implementing these maintenance measures, operators can maximize the cooling efficiency, extend the lifespan of cooling blades, and mitigate the risks of system failures. Prioritizing proactive maintenance practices contributes to the overall operational efficiency and reliability of rotary generators in various power generation applications.

I.8. Blade Retrofitting and Upgrades :

Retrofitting and upgrading rotary generator cooling blades are essential strategies for improving the performance, efficiency and reliability of power generation systems. As technology advances and new cooling solutions emerge, modification of existing cooling blades becomes a viable option to enhance cooling capabilities and overcome limitations in older designs. We will explore the importance of retrofitting and upgrading rotary generator cooling blades, highlighting the benefits and considerations involved in the process.

I.8.1 Blade Design Optimization :

Retrofitting cooling blades offers an opportunity to optimize their design based on advancements in computational modeling, aerodynamics, and material science. By re-evaluating the blade geometry, curvature, spacing, and materials, engineers can improve cooling efficiency, minimize aerodynamic losses, and enhance heat transfer capabilities. The use of advanced computational tools, such as computational fluid dynamics (CFD), aids in simulating and optimizing new blade designs before physical implementation.

I.8.2 Enhanced Heat Transfer Materials :

Upgrading cooling blade materials can significantly improve their heat transfer properties and durability [3]. Advancements in materials science have led to the development of high thermal conductivity materials and coatings specifically designed for efficient heat dissipation. By retrofitting with these advanced materials, cooling blades can enhance their cooling capacity and improve overall system performance.

I.8.3 Integration of Advanced Cooling Technologies :

Retrofitting cooling blades provides an opportunity to integrate advanced cooling technologies into the existing system. For example, the incorporation of liquid cooling channels or heat pipes within the blade structure can enhance heat transfer efficiency, especially in high-temperature applications. Additionally, the integration of smart cooling systems with temperature and airflow sensors enables real-time monitoring and control of cooling performance.

I.8.4 Blade Coating and Surface Treatments :

Coating technologies have evolved, offering improved protection against erosion, corrosion, and heat transfer limitations. Retrofitting cooling blades with advanced coatings, such as thermal barrier coatings or erosion-resistant coatings, can extend their lifespan and enhance their resistance to environmental factors. Surface treatments, such as shot peening or laser texturing, can also be applied to improve the blade's aerodynamic characteristics and reduce flow separation, resulting in improved cooling efficiency.

I.8.5 Computational Modeling and Analysis :

Before implementing retrofitting or upgrades, thorough computational modeling and analysis should be conducted to evaluate the expected performance improvements and potential challenges. Advanced modeling techniques, such as finite element analysis (FEA) and CFD simulations, can provide insights into the expected thermal behavior, flow patterns, and aerodynamic characteristics of the retrofitted cooling blades. This helps in making informed decisions and optimizing the retrofitting process.

I.8.6 Consideration of System Integration :

Retrofitting and upgrading cooling blades should be performed while considering the overall system integration. Changes in blade design or material properties may require modifications in the cooling system infrastructure, including ducting, baffles, and ventilation systems. Integration considerations ensure compatibility between the retrofitted blades and the existing system, optimizing overall cooling performance.

I.8.7 Performance Testing and Validation :

After retrofitting or upgrading the cooling blades, it is essential to conduct rigorous performance testing and validation. This involves monitoring key performance indicators such as heat transfer efficiency, cooling capacity, aerodynamic losses, and system stability. Performance testing verifies the success of the retrofitting process, identifies any potential issues, and allows for fine-tuning to optimize the cooling system's performance.

Retrofitting and upgrading rotary generator cooling blades offer significant opportunities to enhance performance, efficiency, and reliability in power generation systems. Optimized blade design, advanced materials, integration of new cooling technologies, and thorough computational analysis are key considerations in the retrofitting process. By leveraging these strategies, operators can achieve improved cooling efficiency, enhanced heat transfer capabilities, and increased overall system performance, ultimately extending the lifespan and reliability of rotary generator cooling blades in power generation applications

I.9. Environmental Considerations for Rotary Generator Cooling Blades :

It is very important to consider environmental factors that can affect the effectiveness and longevity of these blades. We will explore the environmental considerations associated with rotary generator cooling blades, and highlight the importance of adapting cooling systems to specific environmental conditions to improve performance, sustainability and long-term reliability.

I.9.1 Temperature and Humidity :

Temperature and humidity levels in the operating environment significantly affect the cooling efficiency of generator blades. High ambient temperatures and humidity levels can reduce the cooling capacity of the blades, potentially leading to increased heat accumulation and decreased system performance[1]. It is crucial to consider these factors during the design and operation of cooling systems, implementing appropriate measures to optimize cooling efficiency under varying temperature and humidity conditions.

I.9.2 Airborne Contaminants :

Airborne contaminants, such as dust, pollutants, and industrial emissions, can accumulate on the surface of cooling blades, hindering their heat dissipation capabilities. These contaminants create an insulating layer that reduces the airflow and increases thermal resistance, resulting in decreased cooling efficiency. Regular inspection, cleaning, and maintenance procedures should be implemented to prevent the build-up of contaminants and ensure continuous airflow for effective heat dissipation.

I.9.3 Corrosion and Environmental Degradation :

Rotary generator cooling blades are exposed to the risk of corrosion and environmental degradation, especially in harsh or corrosive environments. Factors such as saltwater exposure, acidic or alkaline conditions, and atmospheric pollutants can accelerate corrosion, leading to deterioration of the blade surfaces and structural integrity. Implementing corrosion-resistant materials, protective coatings, and proactive maintenance practices can mitigate the effects of environmental degradation, extending the lifespan of the cooling blades.

I.9.4 Altitude and Pressure :

The altitude and ambient pressure at a generator's installation site can impact the performance of cooling blades. Higher altitudes with lower air density may affect the cooling efficiency by reducing the airflow and heat transfer capacity. Proper design considerations, including adjustments to blade geometry, surface area, and ventilation systems, should be made to optimize cooling performance at different altitudes and pressure conditions.

I.9.5 Noise and Vibrations :

Rotor blades can generate noise and vibrations during operation, which can have environmental implications. Excessive noise can disturb nearby communities or violate noise regulations [1]. Vibrations can cause mechanical stress on the blades and other components, leading to premature wear or failure. Implementing noise reduction measures, such as acoustic insulation or vibration dampening techniques, contributes to environmental compliance and ensures the long-term integrity of the cooling system.

I.9.6 Energy Efficiency :

In today's environmentally conscious landscape, improving energy efficiency is a key consideration for power generation systems. Efficient cooling blade designs, optimized airflow management, and intelligent control systems can help minimize energy consumption while maintaining optimal cooling performance. By reducing energy requirements, power generation facilities can contribute to sustainability goals and reduce their environmental footprint.

I.9.7 Renewable Energy Integration :

With the increasing integration of renewable energy sources into power grids, cooling systems for rotary generators must adapt to variable operating conditions. Renewable energy sources, such as wind or solar, may have intermittent generation patterns, leading to fluctuating cooling requirements. Flexible cooling strategies, adaptive control systems, and advanced monitoring technologies can optimize cooling efficiency while accommodating the dynamic nature of renewable energy generation.

Environmental considerations are crucial for rotary generator cooling blades to ensure their optimal performance, longevity, and environmental sustainability. Adapting cooling systems to specific temperature, humidity, airborne contaminants, corrosion risks, altitude, pressure, noise, vibrations, and energy efficiency requirements enhances the overall performance and reliability of the cooling blades. By incorporating these environmental considerations, power generation facilities can achieve efficient and sustainable operation while minimizing the environmental impact of rotary generator cooling systems.

I.10. Conclusion:

In conclusion, this chapter has provided a comprehensive exploration of rotary generator cooling blades, focusing on their design, function, and manufacturing. Cooling blades are an indispensable component of the alternator's cooling system, serving the critical purpose of dissipating the heat generated by the rotor. Through a thorough understanding of the various types of cooling blades, their unique advantages, and disadvantages, valuable insights have been gained to optimize the cooling system for improved performance and enhanced reliability.

Chapter II

Modeling and Reverse Engineering for Mechanical Design

II.1. Introduction :

In this chapter, we will delve into the fascinating world of modeling the design of mechanical parts and reverse engineering. These two interconnected practices play a pivotal role in the design, development, and optimization of mechanical components. Modeling the design of mechanical parts involves the creation of virtual representations using computer-aided design (CAD) software, allowing engineers to simulate and analyze the behavior and performance of parts before physical prototyping.

On the other hand, reverse engineering focuses on extracting valuable information from existing physical parts to recreate or modify them digitally. By combining these practices, engineers can refine designs, optimize performance, ensure compatibility, and reduce design iterations, ultimately leading to cost and time savings in the product development process.

Throughout this chapter, we will explore the principles, methodologies, tools, and real-world applications of both modeling the design of mechanical parts and reverse engineering, providing valuable insights into these essential practices in the realm of mechanical engineering.

II.2. Modeling the design of mechanical parts :

II.2.1 Definition of modeling the design of mechanical parts :

Modeling the design of mechanical parts refers to the process of creating virtual representations or digital models that accurately depict the geometry, dimensions, and specifications of mechanical components. It involves utilizing computer-aided design (CAD) software and various modeling techniques to construct three-dimensional (3D) models that simulate the behavior and performance of the parts under different operating conditions. By employing advanced modeling capabilities, engineers can visualize, analyze, and optimize designs before physically prototyping or manufacturing the parts. This enables them to refine the design, identify potential issues, validate performance, and ensure functional compatibility, ultimately leading to improved efficiency, cost-effectiveness, and reliability in the development of mechanical components [9].

II.2.2.Overview of Modeling Techniques and Tools in Mechanical Engineering :

In the field of mechanical engineering, modeling techniques and tools play a crucial role in the design and development of various components. From creating virtual representations to simulating and analyzing performance, engineers rely on a range of modeling techniques and tools to bring their ideas to life [10]. We will provide an overview of the different modeling techniques and tools used in mechanical engineering, highlighting their applications, benefits and key considerations.

1. Solid Modeling:

Definition and Applications:

Solid modeling is a technique used to create three-dimensional (3D) digital representations of objects with well-defined boundaries and geometric properties. It is widely used in mechanical engineering for designing complex parts, assemblies, and mechanisms.

Benefits and Advantages:

Solid modeling enables engineers to visualize and manipulate virtual objects in a realistic manner. It allows for precise geometry creation, facilitates analysis and simulation, supports design modifications, and aids in the detection of interference or collision issues.

2. Surface Modeling:

Definition and Applications:

Surface modeling focuses on creating and manipulating the external surfaces of objects without necessarily defining their interior volume. It is particularly useful for designing aesthetic components, such as car bodies, consumer products, and ergonomic shapes.

Benefits and Advantages:

Surface modeling enables engineers to achieve smooth and curvaceous designs with precise control over the shape and curvature of surfaces. It provides flexibility in design modifications, facilitates aerodynamic analysis, and supports the creation of visually appealing products.

3. Parametric Modeling:

Definition and Applications:

Parametric modeling involves defining and controlling design parameters that drive the shape, size, and behavior of the model. It allows for the creation of intelligent models that can be easily modified and updated, providing flexibility and efficiency in the design process.

Benefits and Advantages:

Parametric modeling enables engineers to explore multiple design iterations by changing a set of parameters. It allows for quick design modifications, automatic updates throughout the model, and facilitates design optimization. It also enhances design reuse and supports design automation.

4. Other Modeling Tools:

Geometric Dimensioning and Tolerancing (GD&T):

GD&T tools enable engineers to define and communicate geometric tolerances, ensuring proper fit, function, and interchangeability of parts in an assembly.

Visualization and Rendering:

Visualization tools enhance the representation of models through realistic rendering, shading, and lighting effects. They aid in design communication, marketing materials, and presentations.

II.2.3. The Significance of Mechanical Part Modeling:

1.Improving Design Efficiency:

By creating virtual representations of mechanical parts, engineers can visualize and analyze their behavior and performance before physically prototyping them. This helps identify design flaws, optimize performance, and streamline the development process, ultimately leading to efficient and cost-effective designs.

2.Enabling Simulation and Analysis:

Modeling enables engineers to simulate various operating conditions, stress analysis, and performance evaluation. This allows for early identification of potential issues and enables design modifications to enhance reliability and functionality.

3.Facilitating Collaboration and Communication:

Virtual models act as a common language for multidisciplinary teams, facilitating effective communication and collaboration throughout the design and development process. This ensures that all stakeholders have a clear understanding of the design intent and can contribute their expertise [9].

II.2.4.Benefits of Modeling in Design and Development:

1. Enhanced Visualization and Conceptualization:

Modeling enables engineers to create virtual representations of mechanical components, providing a clear and realistic visualization of the design. This helps in conceptualizing ideas, identifying design flaws, and facilitating effective communication among team members and stakeholders.

2. Improved Design Iterations and Optimization:

With modeling, engineers can quickly iterate through design modifications and variations without the need for physical prototyping. This accelerates the design process and allows for optimization of parameters, resulting in improved performance, reduced costs, and faster time-to-market.

3. Design Simulation and Analysis:

Modeling enables engineers to simulate and analyze the behavior and performance of mechanical components. Through techniques such as finite element analysis (FEA), engineers can evaluate factors like stress distribution, load-bearing capabilities, and structural integrity, ensuring robust designs and minimizing the risk of failure.

4. Facilitated Collaboration and Iterative Feedback:

Models serve as a common platform for multidisciplinary teams to collaborate and provide iterative feedback. By sharing and reviewing the virtual representation, designers, engineers, and stakeholders can contribute their expertise, identify potential issues, and collectively optimize the design for better outcomes [9].

II.3. Reverse engineering:

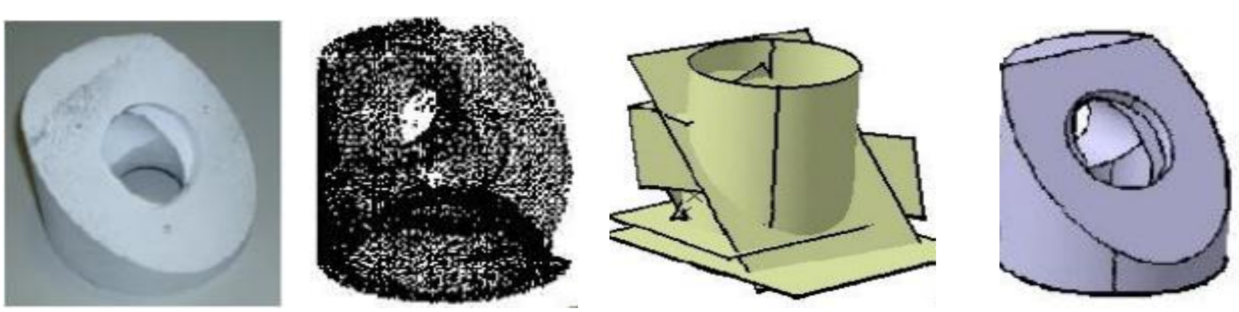
II.3.1. Definition of reverse engineering :

Reverse engineering, also known as rétro-conception or rétro-ingénierie, is an activity that finds application in various fields such as mechanical engineering, electrical engineering, civil engineering, computer science, medicine, aerospace engineering, naval engineering, and more. In mechanical engineering, reverse engineering refers to the process of creating computer-aided design (CAD) files based on a physical object [11]. Specifically, it involves generating a CAD model or file from an existing object or physical part without the use of a technical drawing.

In the domain of mechanical design, reverse engineering is part of a comprehensive process that begins with the digitization or scanning of the object of interest, resulting in the generation of a point cloud. The applications of reverse engineering are diverse, encompassing virtual prototyping, metrology, industrial heritage preservation, and meeting specific industrial needs. Each of these domains utilizes reverse engineering for different industrial reasons, leveraging its capabilities to achieve desired outcomes.

II.3.2. The principle of reverse engineering :

The principle of reverse engineering is based on collecting data in the form of a point cloud derived from the surface of the object, which is scanned digitally using a 3D scanner or probed mechanically (Figure II.1). This point cloud is processed using computer-aided design (CAD) functions that enable the reconstruction of surfaces. From these surfaces, a parametric model is created, where the user defines the final specifications, such as dimensions, interrelation between dimensions, tolerances, and more [11]. The user and the system collaborate in generating the final parametric model, ensuring accuracy and adherence to the desired specifications.



Part **point cloud** **surfacic** **solid**

Figure II.1 : Reverse engineering method steps.

II.3.3. Industrial reasons for reverse engineering:

Reverse engineering can encompass objects as large as an airplane or as small as an electronic chip. It finds application in various stages of a product's lifecycle. This broad application is facilitated by advancements in scanning techniques (such as ROMER) and geometric recognition algorithms, which have greatly improved over the years. There are several concrete industrial reasons that drive the need for reverse engineering. The most important ones include:

1. Addressing the Challenge of Unavailable or Damaged Components :

Worn or broken components for which there is no source of supply. This context applies to more or less old parts that have undergone a change in their geometries due to wear or breakage [12].

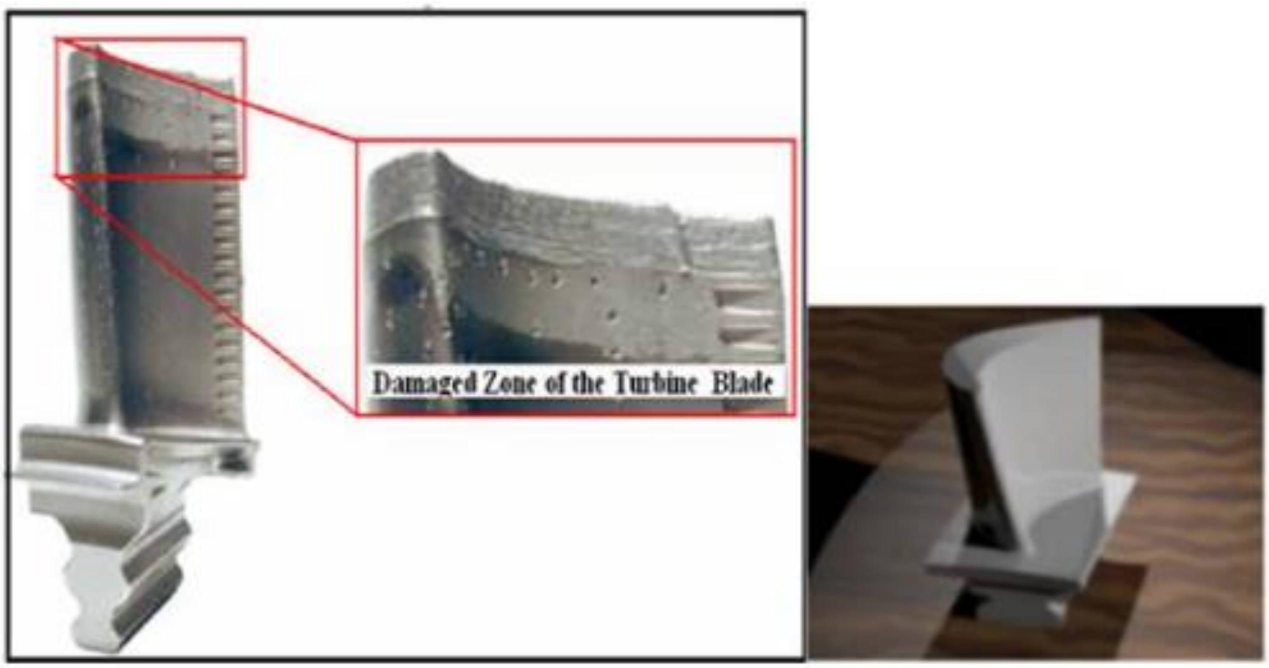


Figure II.2 : Reverse engineering of a worn turbine blade.

2. Challenges of Documenting Original Designs in Museology and Industrial Heritage Preservation :

In situations where the original design lacks sufficient or adequate documentation (Figure II.3), such as in the fields of museology and industrial heritage preservation, there may be a lack of information regarding the product's structure [12]. This means that there are no plans or diagrams available, and only the physical piece itself exists.

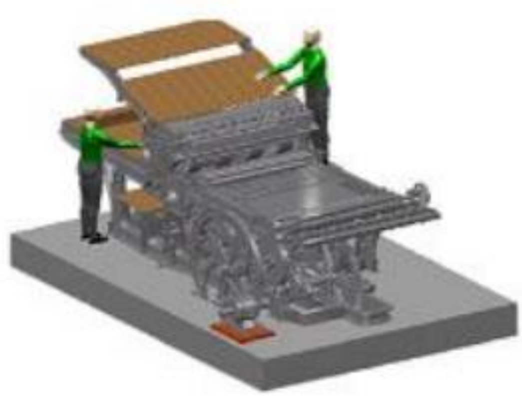


Photo from the printing press CAD model

Figure II.3 : Example of reverse engineering of the printing press.

3. Overcoming Insufficient CAD Models for Modifications through Reverse Engineering :

The original CAD model is insufficient to support modifications. This occurs in cases where certain information has not been provided to the production subcontractor due to industrial property reasons (Figure II.4). In such cases, reverse engineering takes place to make necessary modifications and ensure proper compliance with production requirements.

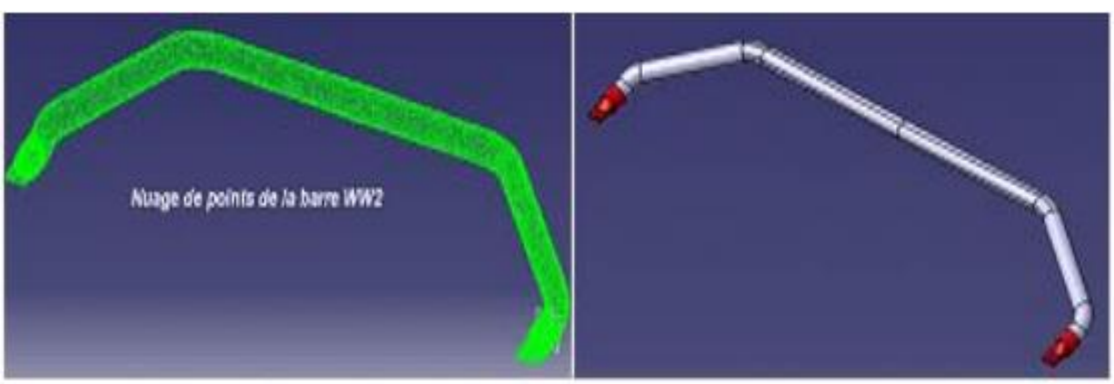


Figure II.4 : The reverse engineering of a stabilizer bar.

4. Reverse Engineering for Manufacturing Obsolete Parts in Absence of Original Manufacturers :

The original manufacturer no longer exists or no longer produces the product, but there is a need to manufacture the product (Figure II.5). This situation often arises with long-lasting parts in the transportation and military sectors. In such cases, reverse engineering aims to enhance the production of obsolete parts and manufacture suitable replacements [12].

Figure II.5 : Reverse engineering of the car plug.

5. Improving Product Performance and Functionality through Design Updates:

Improvement of product performance and/or functionality. This context relates to components that have undergone suboptimal design and necessitate revisions to ensure adequate functionality (Figure II.6).

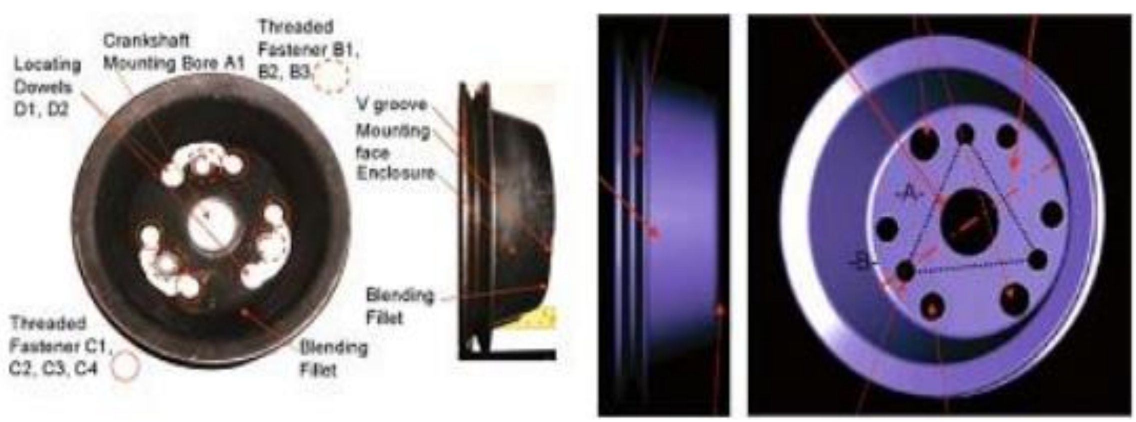


Figure II.6 : Reverse engineering of the power steering pump.

6. Other reasons :

- Lack of additional spare parts.
- Updating outdated materials or manufacturing processes. This situation pertains to older parts. The purpose of reverse engineering in this context is to re-manufacture a part using modern materials and processes.
- Analyzing the features of competitor products: Reverse engineering can also be applied to analyze and acquire knowledge about the manufacturing process, functionalities, and other aspects of a competitor's part. Although this reason may seem obvious, it is often considered secondary to the primary motivations behind reverse engineering.
- Detecting Counterfeits in Competing Products.
- Gaining insights into the design processes of a competitor's product , it is evident that the needs for reverse engineering are broad and diverse, encompassing both older and more modern components. It is clear that the examples mentioned above do not provide a comprehensive synthesis of the industrial reasons involved.

II.3.4. The Importance of Reverse Engineering:

1. Replication and Modification:

Reverse engineering enables the extraction of vital information from existing physical parts, allowing for their replication or modification [13]. This is particularly valuable in scenarios where original design data is unavailable or incomplete, or when product improvements and updates are required.

2. Enhancing Product Life Cycle Management:

Reverse engineering provides insights into legacy parts, enabling manufacturers to extend the life cycle of products, improve compatibility, and reduce maintenance costs. It also aids in the identification of potential design enhancements or component replacements.

3. Quality Control and Inspection:

Reverse engineering allows for detailed inspection and analysis of physical parts, aiding in quality control, defect detection, and conformity assessment. It enables the comparison of manufactured parts against design specifications, ensuring compliance and identifying deviations.

II.3.5. Benefits of Reverse Engineering in Design and Development:

1. Replication and Modification:

Reverse engineering allows engineers to extract valuable information from existing physical parts, enabling their replication or modification. This is particularly valuable when original design data is unavailable, enabling manufacturers to recreate or improve upon legacy parts.

2. Enhanced Product Life Cycle Management:

Reverse engineering provides insights into existing components, allowing manufacturers to extend the life cycle of products. By analyzing and understanding legacy parts, engineers can make informed decisions about repairs, replacements, and upgrades, ensuring compatibility and reducing downtime [13].

3. Quality Control and Inspection:

Reverse engineering enables detailed inspection and analysis of physical parts. By comparing manufactured parts against the original design specifications, engineers can ensure quality control, identify deviations, and address manufacturing inconsistencies, resulting in improved product quality and customer satisfaction.

4. Design Innovation and Upgrades:

Reverse engineering can be a catalyst for design innovation. By examining and understanding existing components, engineers can identify opportunities for improvements, material substitutions, and enhanced functionality, leading to innovative design solutions and market differentiation.

II.4. The Interconnection of Modeling and Reverse Engineering:

1. Iterative Design Refinement:

Modeling and reverse engineering are mutually beneficial processes that complement each other. Feedback from reverse engineering can drive design refinements and improvements in subsequent iterations, leading to optimized designs.

2. Bridging the Gap between Physical and Virtual Domains:

Reverse engineering enables the transfer of information from the physical realm to the virtual world, while modeling allows for the creation of virtual representations that can guide physical manufacturing processes. This interconnection bridges the gap between physical and virtual domains, facilitating seamless integration and collaboration.

3. Continuous Improvement and Innovation:

The interconnection of modeling and reverse engineering fosters a culture of continuous improvement and innovation. By leveraging the insights gained from reverse engineering, engineers can refine designs, enhance performance, and explore new possibilities in product development.

II.5. CAD software

II.5.1. CAD software definition :

CAD software, which stands for Computer-Aided Design software, is a computer-based tool used in various industries for the creation, modification, analysis, and documentation of digital designs. It provides engineers, architects, designers, and other professionals with the ability to create precise and detailed two-dimensional (2D) and three-dimensional (3D) models of objects, components, buildings, and systems. CAD software offers a wide range of tools and features that facilitate the design process, including drawing and drafting tools, geometric modeling capabilities, parametric design functionality, simulation and analysis tools, and documentation tools for generating accurate technical drawings and specifications. CAD software greatly enhances the efficiency and accuracy of the design process, enabling users to visualize and evaluate their designs before physical prototyping or manufacturing [15]. It has become an indispensable tool in modern design and engineering, revolutionizing the way products and structures are conceptualized, developed, and brought to life.

II.5.2. Evolution of CAD Software :

The origins of CAD software can be traced back to the 1960s when computer graphics and design technologies were in their infancy. Early systems required expensive mainframe computers and were primarily used in large-scale industrial applications. However, with advancements in computing power and the advent of personal computers, CAD software became more accessible to a broader audience.

Over the years, CAD software has evolved significantly, incorporating features like 3D modeling, parametric design, simulation, and collaboration tools. Today, modern CAD software offers a wide range of capabilities that cater to the diverse needs of professionals across industries.

II.5.3. Benefits of CAD Software :

CAD software offers numerous benefits that significantly enhance the design and development process. Let's explore some of the key advantages:

1. Increased Productivity :

CAD software streamlines the design process by automating repetitive tasks and providing a wide range of tools and functionalities. With features like parametric modeling and design libraries, designers can quickly create and modify designs, saving significant time and effort. Additionally, CAD software enables easy reuse of design elements, ensuring consistency across projects and further boosting productivity [15].

2. Enhanced Accuracy and Precision :

One of the standout advantages of CAD software is its ability to produce highly accurate and precise designs. With the help of advanced measurement tools, grid systems, and snap options, designers can create geometry with unparalleled accuracy. The software also allows for easy modification and fine-tuning, ensuring that the final design meets all specifications and requirements.

3. Realistic Visualization and Simulation :

CAD software enables designers to visualize their creations in a realistic 3D environment. By rendering models with materials, textures, and lighting effects, professionals can evaluate the aesthetics and functionality of their designs before they are physically realized. Additionally, CAD software often includes simulation features that allow for testing and analysis, ensuring that the design performs optimally in real-world conditions.

4. Cost and Time Savings

By leveraging the capabilities of CAD software, businesses can save both time and money throughout the design and development process. The software helps eliminate costly errors early on, reducing the need for rework and avoiding expensive prototyping. Furthermore, the streamlined design process and improved productivity translate into faster time-to-market, giving businesses a competitive edge [15].

II.5.4. CAD Software: Comprehensive Analysis Capabilities

CAD software goes beyond design creation by incorporating analysis functionalities that enable professionals to delve deeper into the performance and behavior of their designs. Here are some key analysis capabilities offered by CAD software:

1. Finite Element Analysis (FEA) :

Finite Element Analysis (FEA) is a powerful tool available in CAD software that enables engineers to simulate the behavior of designs under different conditions. By breaking down complex structures into smaller elements, FEA analyzes factors such as stress distribution, deformation, and vibration. This allows designers to identify potential weaknesses, optimize designs, and ensure structural integrity.

2. Computational Fluid Dynamics (CFD) :

Computational Fluid Dynamics (CFD) is another analysis capability provided by CAD software. It enables engineers to simulate fluid flow and heat transfer within designs, such as airflow around a vehicle or thermal management in electronic devices. CFD analysis helps optimize performance, improve energy efficiency, and enhance the overall functionality of designs.

3. Assembly and Interference Analysis :

CAD software allows professionals to analyze assemblies and detect potential interferences or clashes between components. This analysis capability ensures that all parts fit together properly and function as intended. By identifying and resolving interferences early in the design process, CAD software saves time, minimizes errors, and prevents costly rework during manufacturing or construction [16].

4. Structural Analysis :

Structural analysis capabilities in CAD software enable engineers to assess the strength, stability, and load-bearing capacity of designs. By applying various forces, such as static loads or dynamic forces, designers can analyze how a structure will perform under different conditions. This analysis helps optimize material usage, identify potential failure points, and ensure designs meet safety standards and regulatory requirements.

5. Thermal Analysis :

Thermal analysis capabilities in CAD software enable engineers to evaluate how designs behave under different temperature conditions. By simulating heat transfer, thermal stress, and thermal management, designers can optimize cooling systems, prevent overheating, and ensure proper functioning of electronic components or machinery.

II.5.5. Industries and Applications :

CAD software finds applications across a wide range of industries, empowering professionals in various fields. Some key industries that extensively utilize CAD software include:

1. Architecture and Construction :

Architects and construction professionals rely on CAD software to create detailed architectural plans, 3D models, and construction documentation. The software enables them to visualize spaces, optimize designs, and accurately communicate their ideas to clients and contractors.

2. Manufacturing and Engineering :

In the manufacturing and engineering sectors, CAD software plays a pivotal role in designing and developing complex products and machinery. It allows engineers to create intricate 3D models, perform simulations, and generate detailed manufacturing specifications, ensuring efficient production processes.

3. Automotive and Aerospace :

The automotive and aerospace industries heavily rely on CAD software for designing vehicles, aircraft, and their components. CAD software enables engineers to create aerodynamic designs, analyze structural integrity, and simulate performance under different conditions. This leads to the development of safer, more efficient, and aesthetically pleasing vehicles and aircraft.

4. Product Design and Consumer Goods :

From consumer electronics to household appliances, CAD software is instrumental in the design and development of various consumer goods. Designers can create visually appealing product concepts, validate ergonomics, and simulate assembly processes, resulting in the creation of innovative and user-friendly products.

5. Medical and Healthcare :

the medical field, CAD software finds applications in areas such as prosthetics, orthotics, and dental restorations. It allows medical professionals to create custom-fit designs, perform simulations for surgical planning, and produce accurate models for 3D printing, ultimately improving patient outcomes.

II.6. Conclusion :

In conclusion, the chapter has provided a comprehensive exploration of the fascinating world of modeling the design of mechanical parts and reverse engineering. These two interconnected practices have proven to be pivotal in the design, development, and optimization of mechanical components. By utilizing computer-aided design (CAD) software, engineers can create virtual representations of parts, enabling them to simulate and analyze behavior and performance before physical prototyping.

On the other hand, reverse engineering allows engineers to extract valuable information from existing physical parts, facilitating the recreation or modification of these parts digitally. The combination of these practices offers numerous benefits in the product development process. By refining designs, optimizing performance, ensuring compatibility, and reducing design iterations, engineers can achieve significant cost and time savings.

Throughout the chapter, we have delved into the principles, methodologies, tools, and real-world applications of modeling the design of mechanical parts and reverse engineering. From examining the fundamentals of CAD software to understanding the techniques involved in reverse engineering, we have provided valuable insights into these essential practices in the realm of mechanical engineering.

The knowledge gained from this chapter will empower engineers to make informed decisions, enhance their design processes, and overcome challenges in mechanical part design and development. As technology continues to advance, the utilization of modeling and reverse engineering will only become more prevalent, enabling engineers to push the boundaries of innovation and create superior mechanical components.

Chapter III

Design Modeling Process for a Cooling Blade

III.1. Introduction :

The design modeling process for a cooling blade is a complex and multi-step process that requires a deep understanding of various software tools and technologies. This chapter aims to provide an in-depth overview of this process, starting with the basics of Solidworks, Geomagic Design X, and Abaqus. These software tools are essential for creating accurate 3D models of the cooling blade and simulating its performance under different conditions.

The chapter then moves on to discuss the 3D scanner used to scan the cooling blade. The Scanner Steinbishler Comet L3D 8MP is a powerful tool that can capture high-resolution 3D images of complex geometries. The scanner is an essential part of the reverse engineering process, which involves creating a digital model of the cooling blade based on its physical dimensions.

Finally, the chapter discusses the cooling blade design modeling process. This process includes creating a detailed 3D model of the blade using Solidworks and Geomagic Design X, simulating its performance using Abaqus, and comparing the final design to the company's original design.

III.2. Definition of CAD software used in modeling blade design :

III.2.1. Definition of Solidworks :

SolidWorks is a computer-aided design (CAD) software that is widely used in various industries for designing and modeling 3D objects. Developed by Dassault Systèmes, SolidWorks offers a user-friendly interface and powerful tools for creating, simulating, and documenting intricate designs.

At its core, SolidWorks allows users to construct three-dimensional models virtually. It provides a range of intuitive features and commands that enable the creation of complex shapes and designs. Users can start with basic shapes and then use SolidWorks' extensive set of sketching and modeling tools to refine and manipulate these objects into detailed designs [20].

II.2.2. Definition of Geomagic Design X :

Geomagic Design X is a professional software solution for reverse engineering and 3D scanning applications. Developed by 3D Systems, Geomagic Design X provides a powerful set of tools and functionalities to convert physical objects into digital 3D models with high precision and accuracy.

The primary purpose of Geomagic Design X is to capture the geometry of existing objects, whether they are physical prototypes, parts, or even complex organic shapes. This software is commonly used in industries such as manufacturing, automotive, aerospace, and healthcare, where the need to replicate or modify existing physical objects arises.

With Geomagic Design X, users can import data from various 3D scanning devices, such as laser scanners or structured light scanners. The software then processes this data to create a detailed and accurate 3D representation of the scanned object. It uses advanced algorithms and tools to stitch together multiple scans, clean up noise or imperfections, and align the data into a cohesive model.

II.2.3. Definition of Abaqus :

Abaqus is a widely used commercial finite element analysis (FEA) software package developed by Dassault Systèmes. It is specifically designed for simulating and analyzing the behavior of structures and materials under various loading conditions.

Abaqus allows engineers and researchers to create virtual models of complex systems or components and simulate their response to different mechanical, thermal, and multiphysics environments. It offers a wide range of capabilities for conducting static, dynamic, and nonlinear analyses, making it suitable for a diverse range of applications in industries such as aerospace, automotive, civil engineering, and biomechanics [21].

One of the key features of Abaqus is its ability to handle complex geometries and materials. Users can create detailed 3D models of structures, including intricate shapes, assemblies, and connections. The software supports a variety of element types, such as solids, shells, and beams, enabling accurate representation of different components.

II.3. Overview of the 3D scanner used to scan the cooling blade (Scanner Steinbishler Comet L3D 8MP) :

The Scanner Steinbichler Comet L3D 8MP is a high-resolution 3D scanning system used for capturing detailed geometric information of physical objects. It is developed by Steinbichler, a company specializing in optical metrology solutions.

The Comet L3D 8MP scanner utilizes advanced laser triangulation technology to capture the surface geometry of objects with exceptional accuracy and precision. It projects a laser line onto the object's surface and captures the reflection of the laser line with its high-resolution cameras. By analyzing the distortions and deviations of the captured laser line, the scanner calculates the 3D coordinates of points on the object's surface, allowing for the creation of a digital representation of the object.

Figure III.1 : Scanner Steinbishler Comet L3D 8MP.

With its 8-megapixel (8MP) camera resolution, the scanner can capture fine details and intricate features of objects with high fidelity. This makes it suitable for applications that require precise measurements and accurate representation of complex shapes and surfaces.

The Scanner Steinbichler Comet L3D 8MP offers versatility in terms of object size and material compatibility. It can scan objects ranging from small components to large structures, providing flexibility in capturing a wide range of objects. It can handle various materials, including plastics, metals, composites, ceramics, and organic materials.

Figure III.2 : Scan of a mechanical part.

The scanner is equipped with user-friendly software that allows for efficient data acquisition and processing. The software provides tools for aligning and merging multiple scans, cleaning up noise or artifacts, and generating a complete 3D model of the scanned object. It also supports export formats that enable the seamless integration of the acquired data with other software applications for further analysis or 3D printing [22].

Overall, the Scanner Steinbichler Comet L3D 8MP is a high-resolution 3D scanning system that offers exceptional accuracy and versatility. It enables the capture of detailed geometry of objects, making it valuable in industries such as manufacturing, reverse engineering, quality control, and product development.

II.4. Steps involved in modeling a cooling blade design :

This process involves a series of steps, from reverse engineering the cooling blade design to simulating and comparing objects to improve performance. By following this systematic approach, the engineers were able to test the cooling blade in various conditions without the need for a real prototype.

II.4.1. Obtain the physical cooling blade :

The step of obtaining the physical cooling blade in the context of reverse engineering refers to the process of acquiring the actual blade that you intend to model and analyze. This involves obtaining physical access to the cooling blade itself, whether it is an existing component or a prototype.

When obtaining the physical cooling blade, it is essential to ensure that you have a clear understanding of its dimensions, features, and purpose. This means gathering detailed information about the blade's physical measurements, such as length, width, thickness, and any other relevant dimensions. Additionally, you should familiarize yourself with the specific features of the cooling blade, such as the arrangement of cooling channels, fins, or other structures that aid in heat dissipation.

Figure III.3 : Rotary generator cooling blade.

II.4.2. 3D Scanning :

Cooling blade 3D scanning using the Steinbichler Comet L3D 8MP scanner with a 360-degree scanning method is an advanced technique used to capture the precise geometry and intricate details of cooling blades in a three-dimensional digital format. This scanning method offers a comprehensive and thorough approach to obtain a complete representation of the cooling blade's surface, enabling accurate analysis, reverse engineering, and design optimization.

The Steinbichler Comet L3D 8MP scanner, renowned for its high-resolution capabilities and precision, is employed in this process to ensure the capture of fine details and intricate features of the cooling blade. With its 360-degree scanning method, the scanner enables the comprehensive scanning of the entire cooling blade surface, allowing for a holistic representation and analysis.

After the scanning process, we get the scanning file as shown :

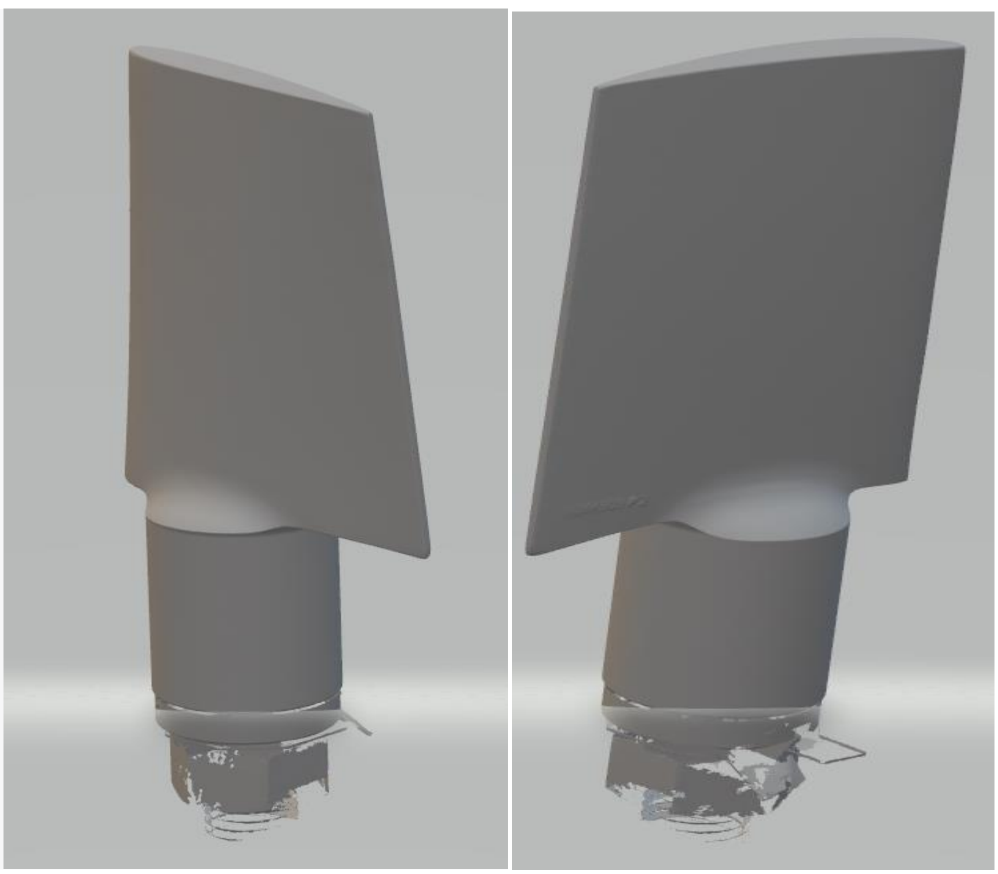


Figure III.4 : 3D scanning file of cooling blade.

II.4.3. Import Point Cloud/Mesh and Cleaning with editing :

By importing the point cloud or mesh into Geomagic, users gain access to a variety of tools and functionalities for data processing and editing. The software allows for efficient manipulation and refinement of the imported data to create a more accurate and usable 3D model.

One important aspect of the editing process is cleaning the point cloud or mesh. This involves removing any noise, artifacts, or unwanted elements from the data. Geomagic provides a range of editing tools that allow users to selectively delete or modify points or polygons, smooth out irregularities, fill gaps, or remove outliers. Cleaning the data ensures that the resulting 3D model is more accurate, visually pleasing, and suitable for subsequent modeling or analysis tasks.

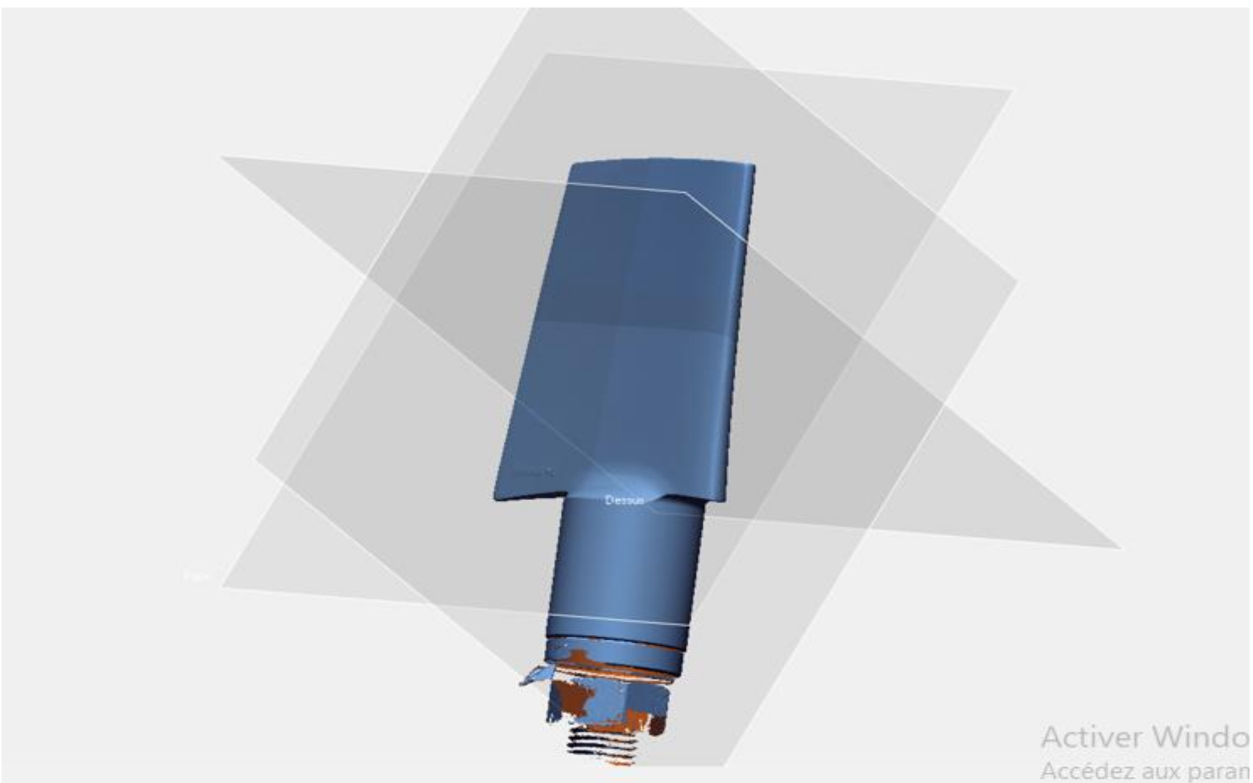
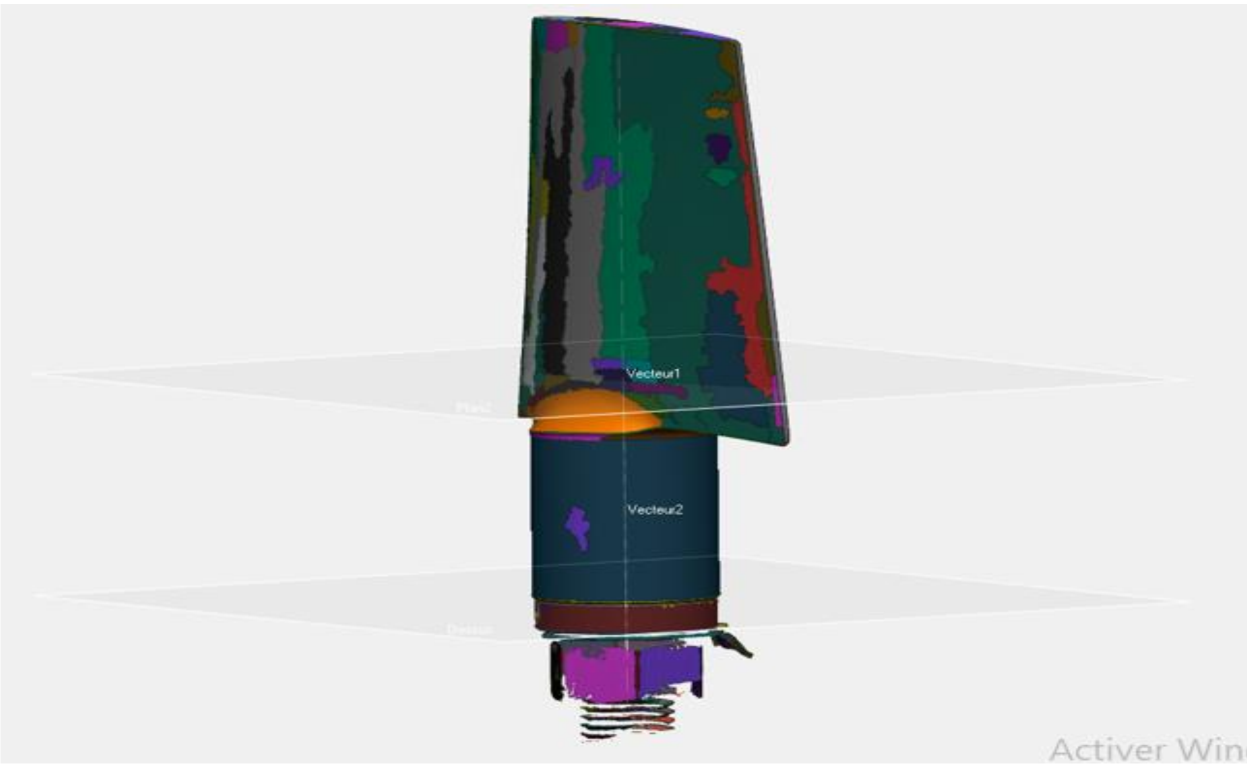


Figure III.5 : The Virtual Prototype of the cooling blade after the cleaning process.

II.4.4. Design process :

1. Rotary generator cooling blade design:

Using Geomagic software, We will use a point cloud-based approach to model the cooling blade. We will illustrate this process through pictures accompanied by annotations.



-We open a scan file using Geomagic software.

- Click on the Auto segment box 

in order for the program to recognize the mechanical piece.

- Click on the vector box 

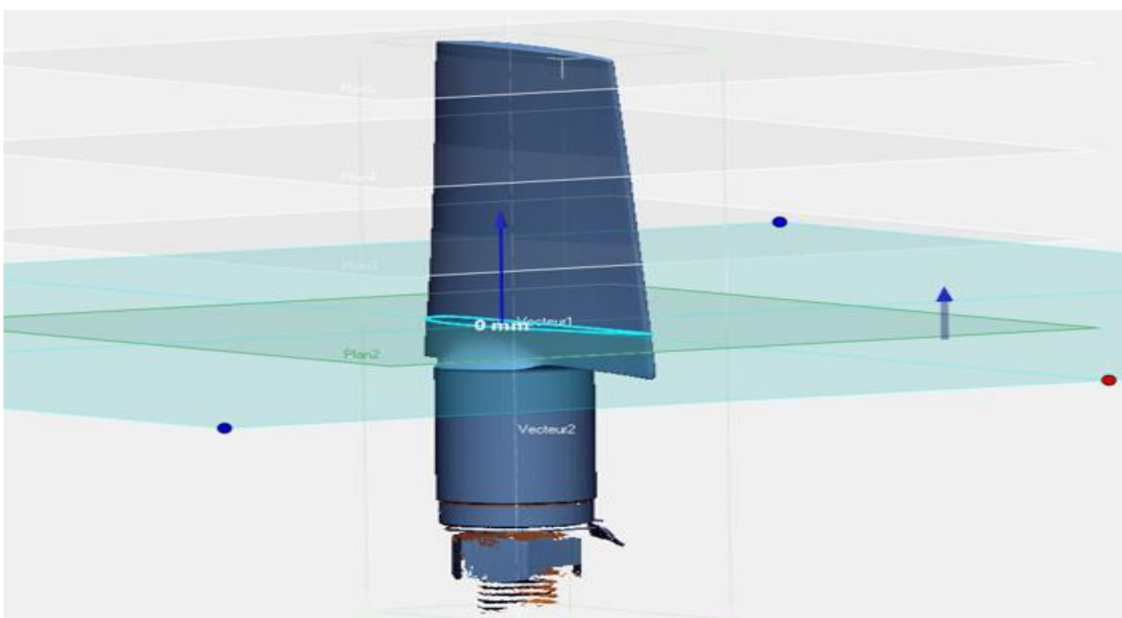
and create vector1,vector2.

- Adjust plane Front ,Top and Right by vector1 and vector2.

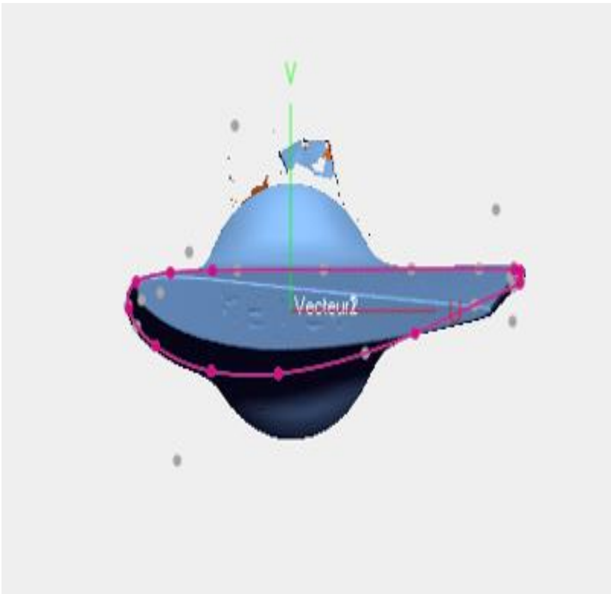
- Click on the Plane box 

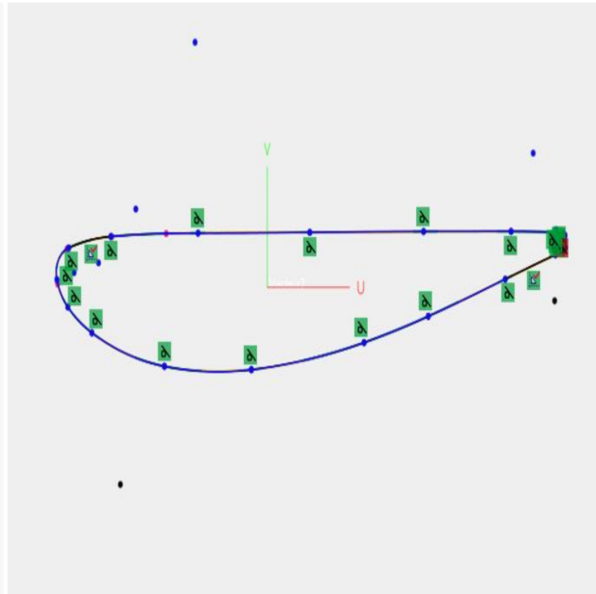
and create Plane2 parallel with Plane Top.

- Create Plane3, Plane4 and Plane5 parallel with Plane2.

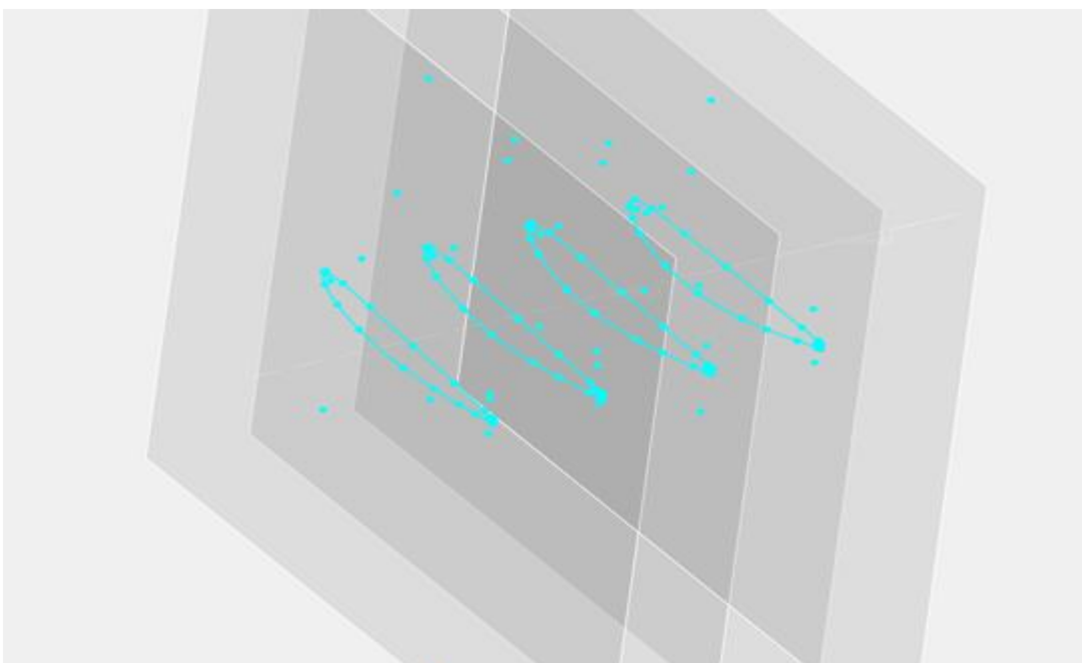


- Choose Plane2 Then we click on the right mouse button and select sketch.



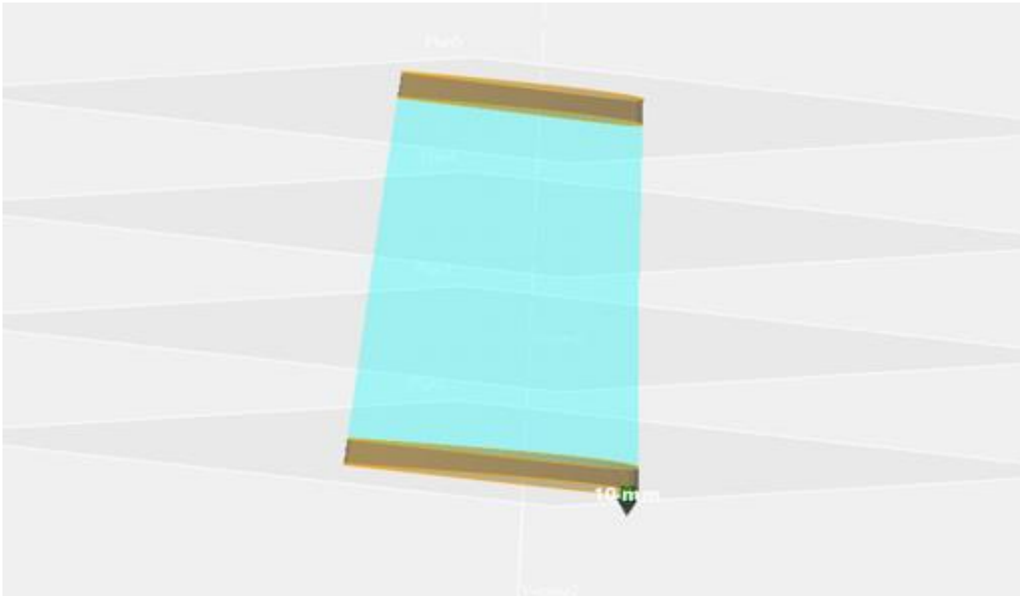


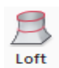
- Draw over the form with a limit value of deviation (0.02) .

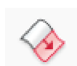


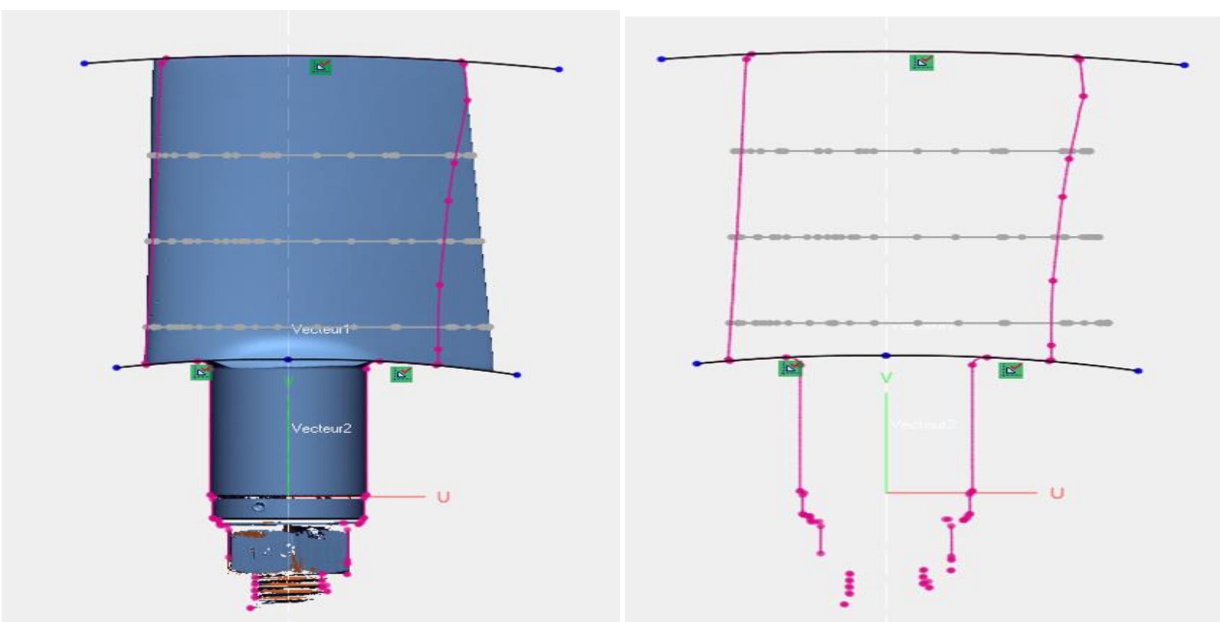
- Do the same operation with Plane3, Plane4 and Plane5.

- Parallelize all the points on the four Planes.



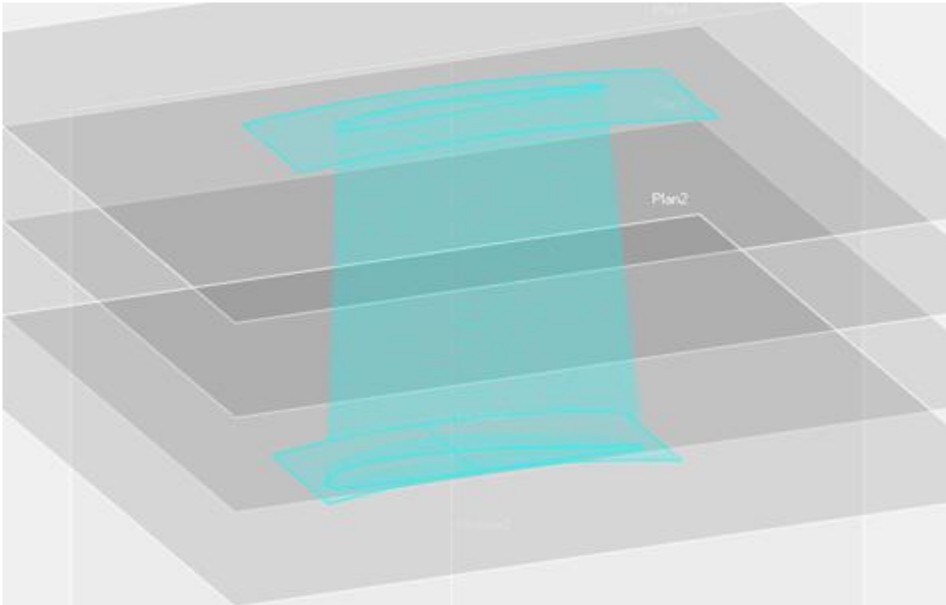
- Click on the Loft box  And choose from each Plane a point that is on one straight line.

- Click on the Extend Surface box  Then increase 10 mm on both sides.



- Choose Plane Front Then we click on the right mouse button and select sketch.

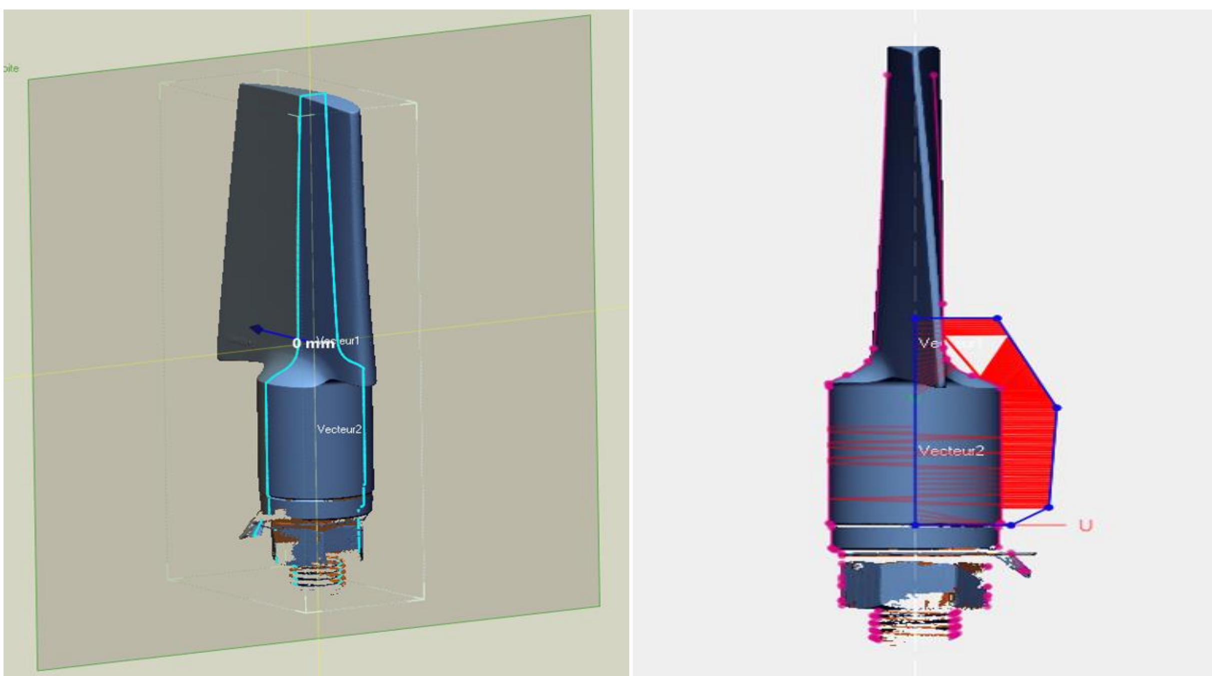
- Draw two curves identical to the form on both edges of the blade.



- Click on the Extrude box 

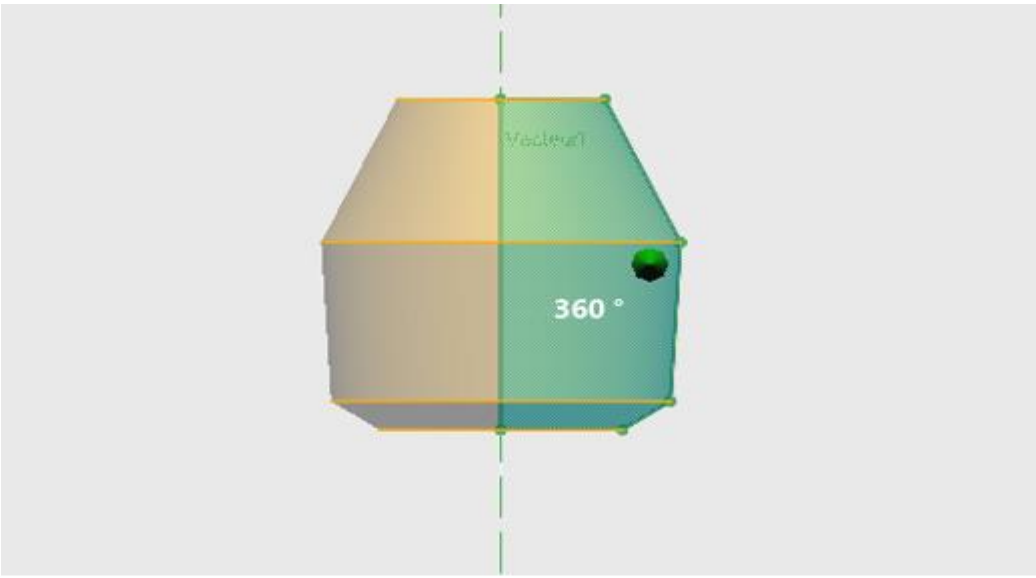
Then write the value of the length 30 mm in both directions.

- Click on the Solidify box.

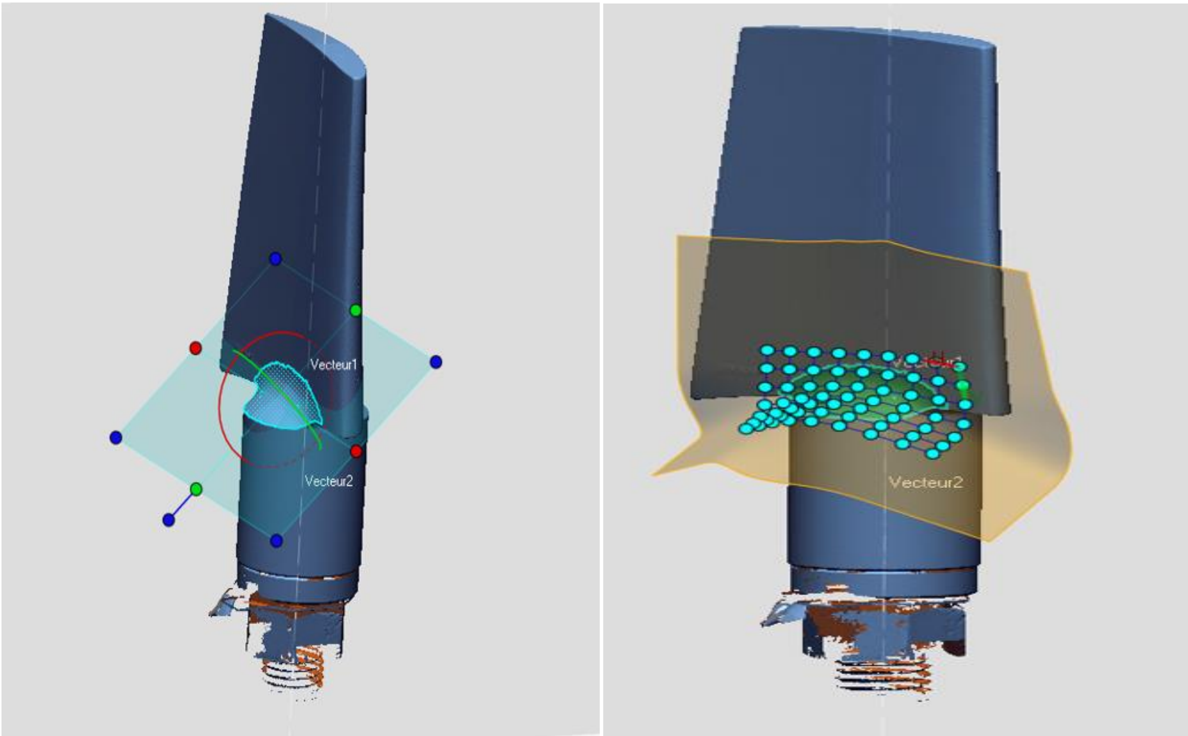


- Choose plane Right Then we click on the right mouse button and select sketch.

- Draw the corresponding figure.

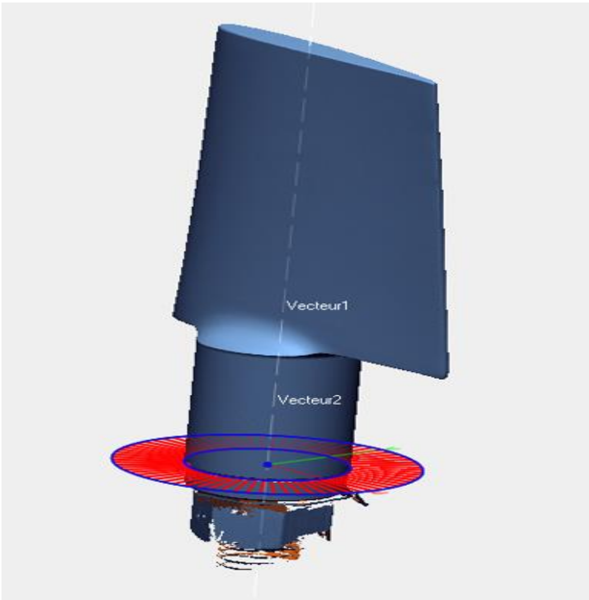


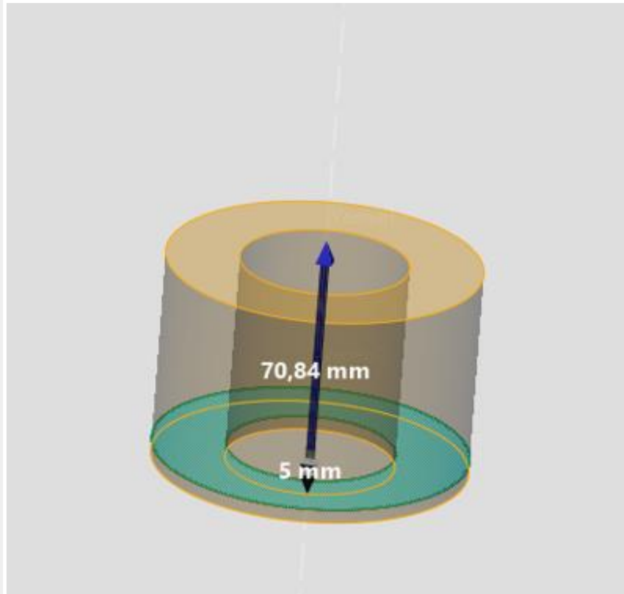
- Click on the Revolve box  and choose the angle 360°.



- Click on the Mesh Fit box  and we choose the area to be removed.

- Repeat the process on the opposite side.





- Choose plane Top Then we click on the right mouse button and select sketch.

- Draw two circles then click on the Extrude box  and choose Cut.

After completing these steps, the result will appear as follows :

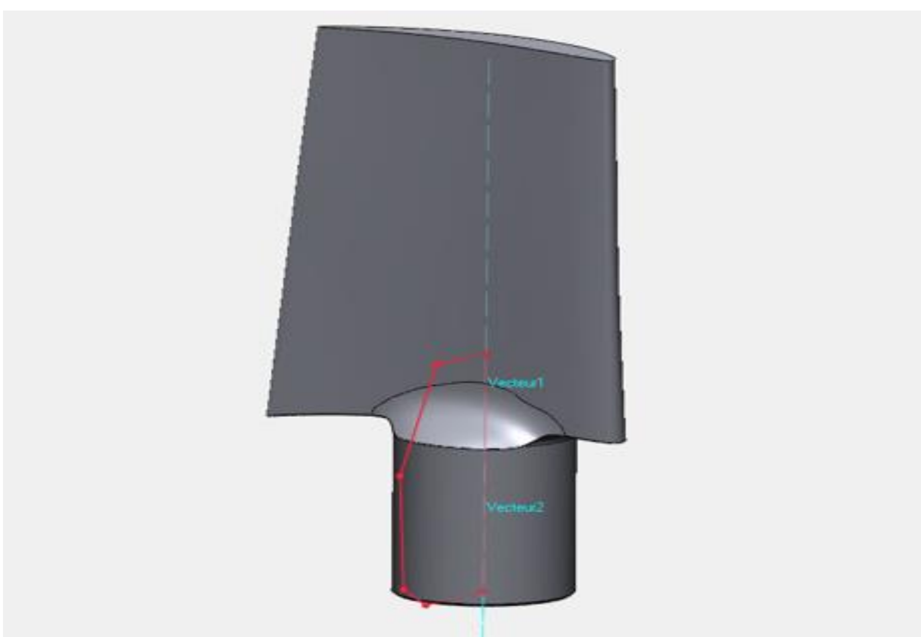
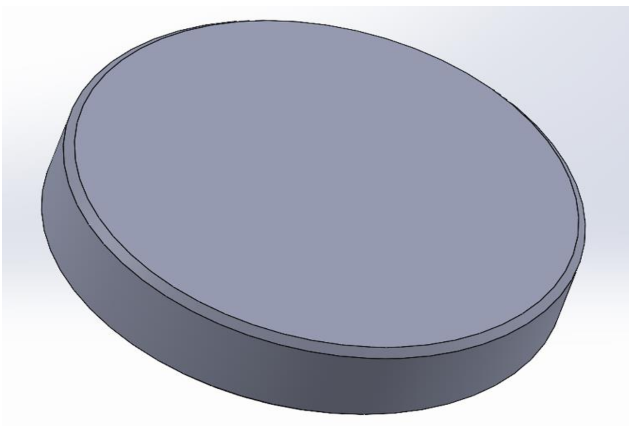
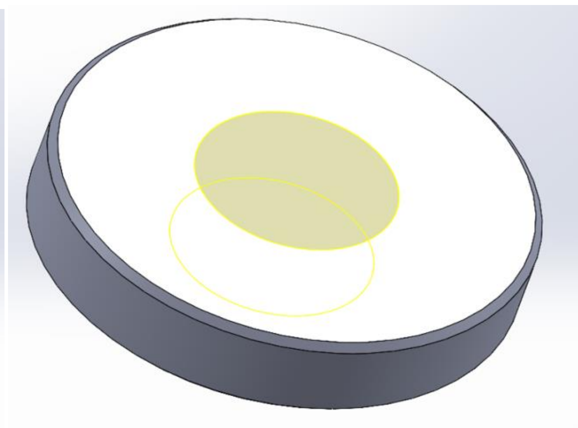


Figure III.6 : The virtual Prototype for Cooling blade.

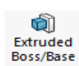
2. The design of the simple part (fixing part) of the cooling blade:

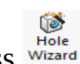
Using the Solidworks program, we will design the fixing part of the cooling blade consisting of : Écrou , Rondelle and Headless screw. We will illustrate this process through pictures accompanied by annotations.





- Choose plane Top Then we click on the right mouse button and select sketch.

-Draw a circle, then tap 

and enter the value 12mm then press 

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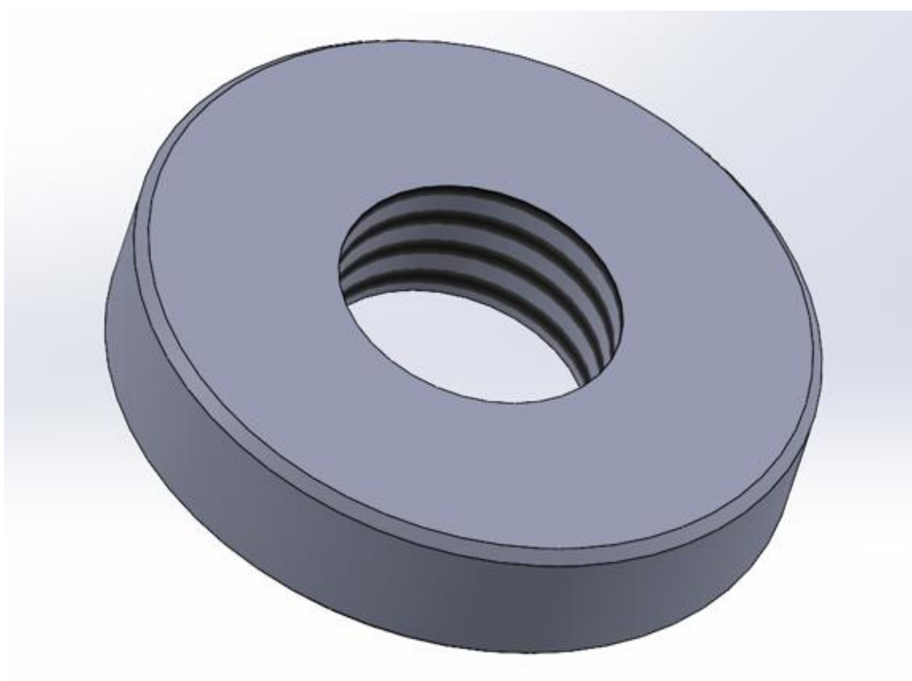
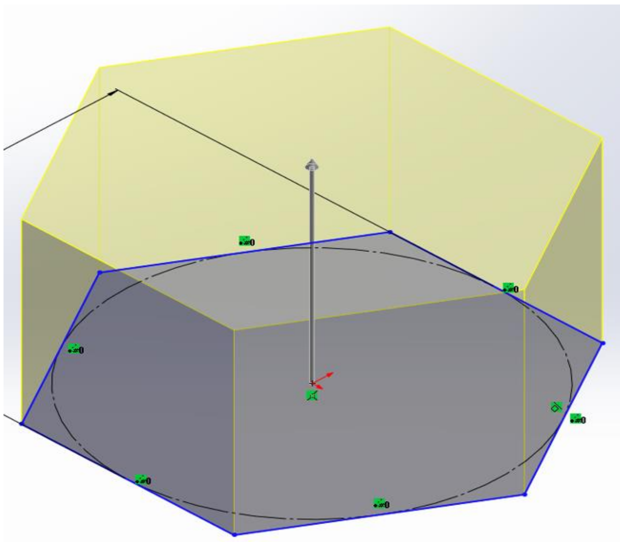
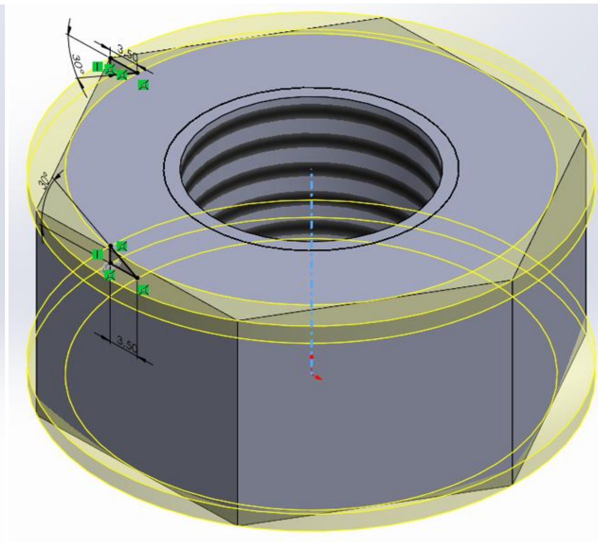
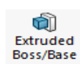


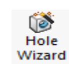
Figure III.7 : The final virtual Prototype for Rondelle.





- Choose plane Top Then we click on the right mouse button and select sketch.

-We draw a hexagon, then tap 

and enter the value 24mm then press 

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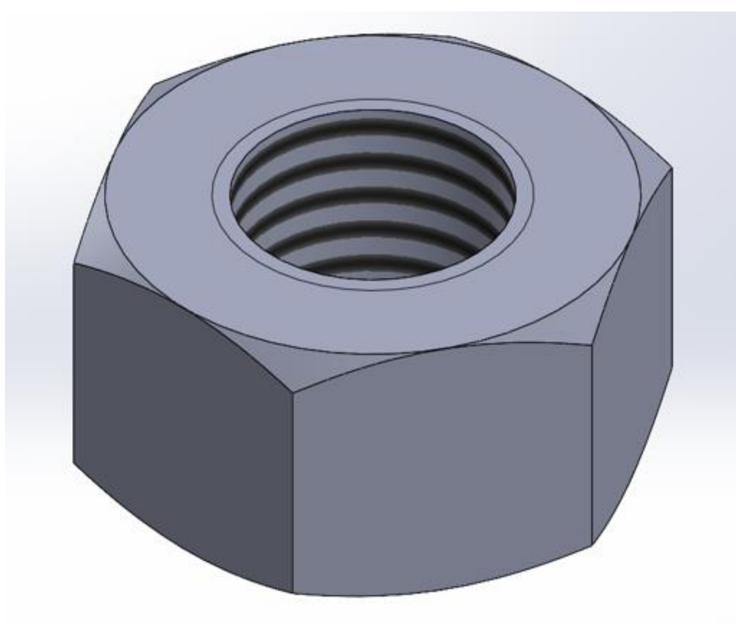
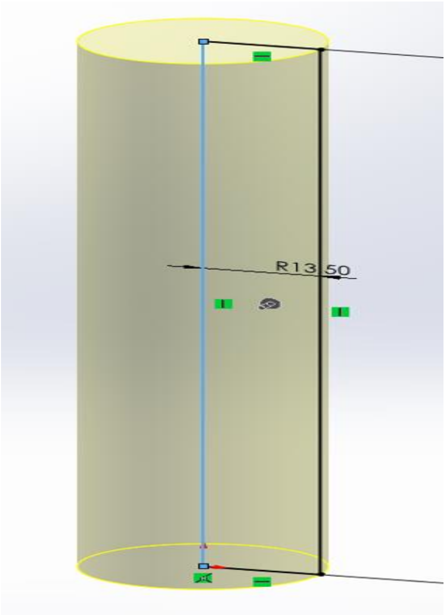
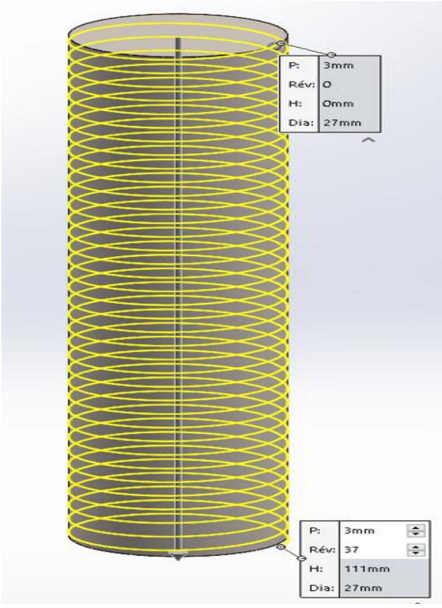
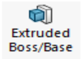


Figure III.8 : The final virtual Prototype for Écrou.





- Choose plane Top Then we click on the right mouse button and select sketch.

-Draw a circle, then tap 

and enter the value 110mm then press .

Figure III.9 : The final virtual Prototype for Headless screw.

II.4.5. Import CAD Model to SolidWorks:

The next step is to import the CAD model into SolidWorks. The most common formats are STEP or IGES.

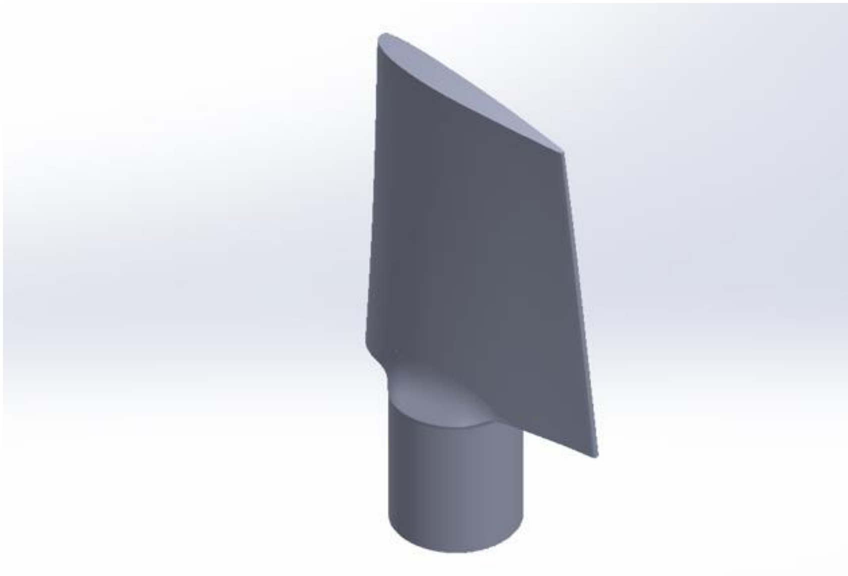


Figure III.10 : The virtual Prototype for cooling blade in Solidworks.

II.4.6. Assembly :

In this step, we assemble the cooling blade with the fixing parts.

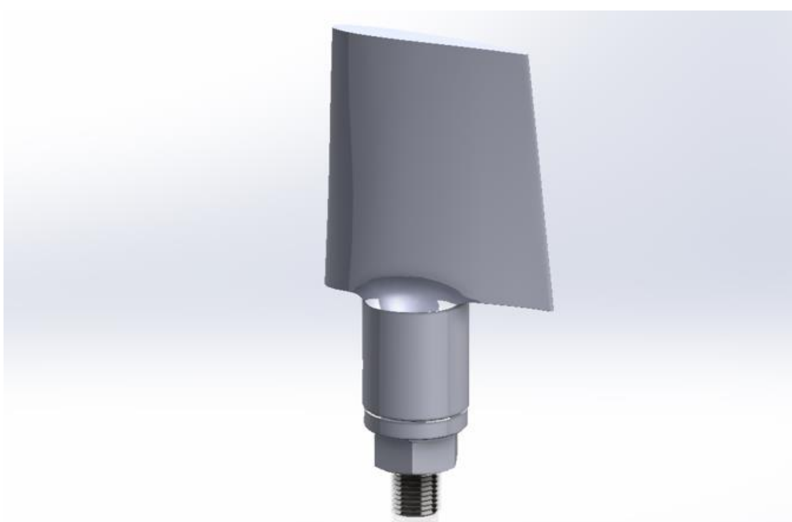


Figure III.11 : The final virtual Prototype for Rotary generator cooling blade.

II.4.7. Manufacturing Documentation:

Once the design is completed, we create manufacturing documentation such as 2D drawings for all mechanical parts.

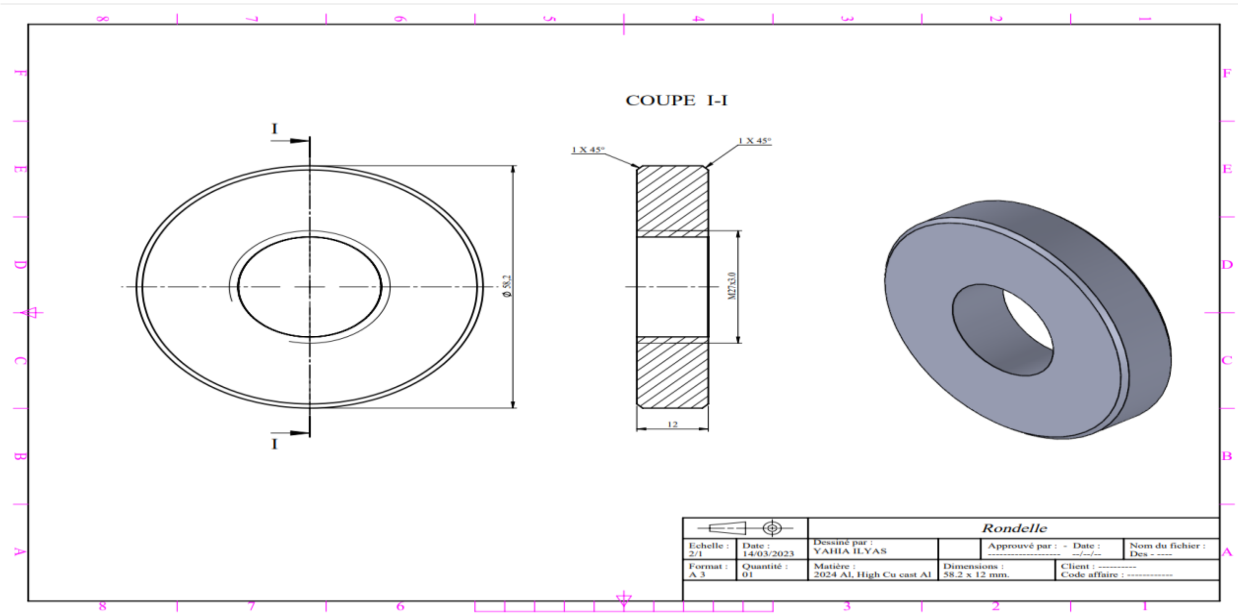


Figure III.12 : Manufacturing document for Rondelle.

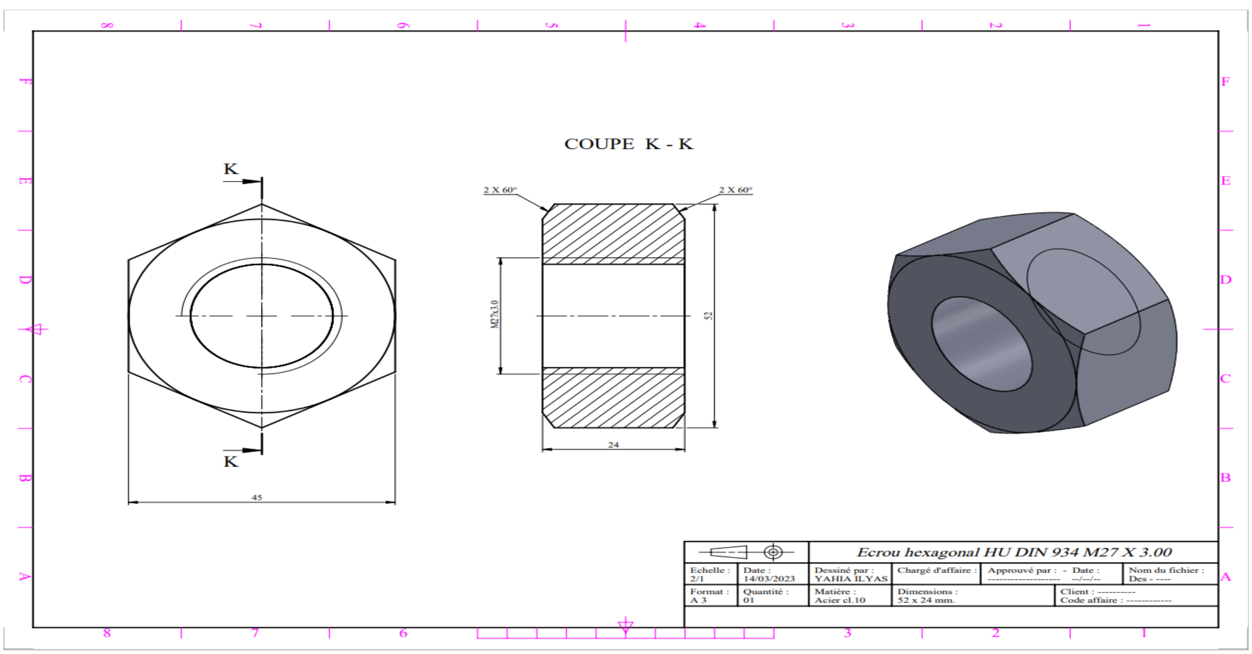


Figure III.13 : Manufacturing document for Ecrou hexagonal.

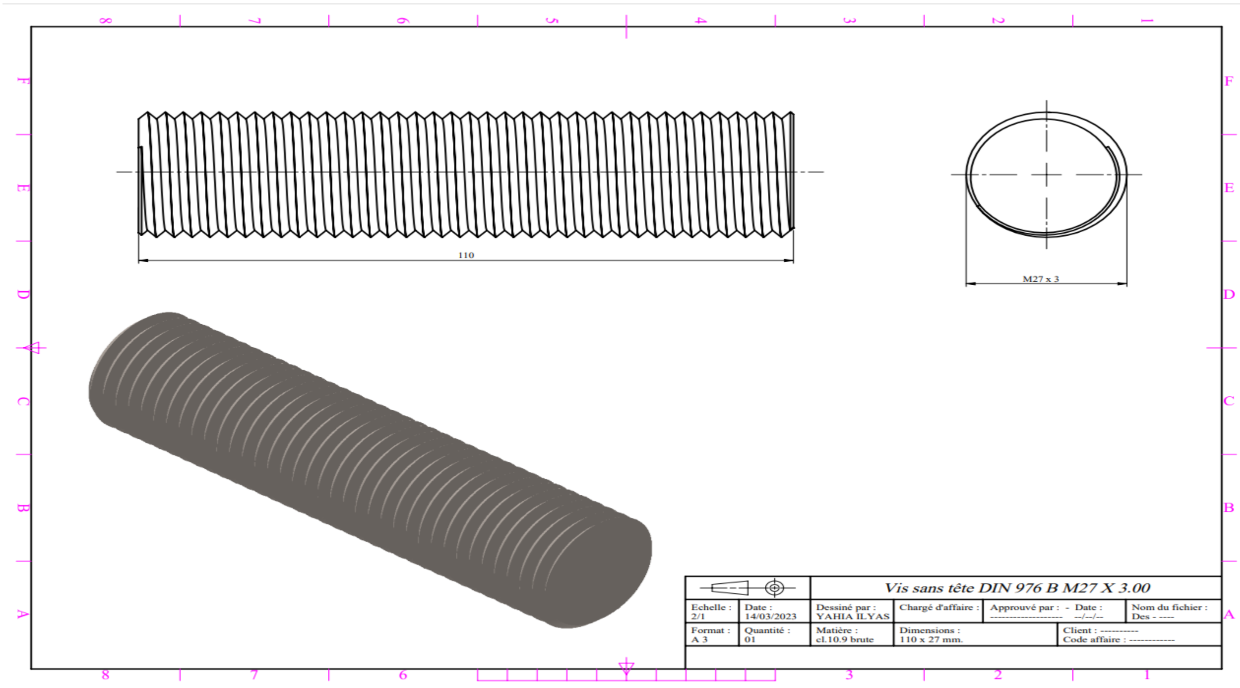


Figure III.14 : Manufacturing document for Headless screw.

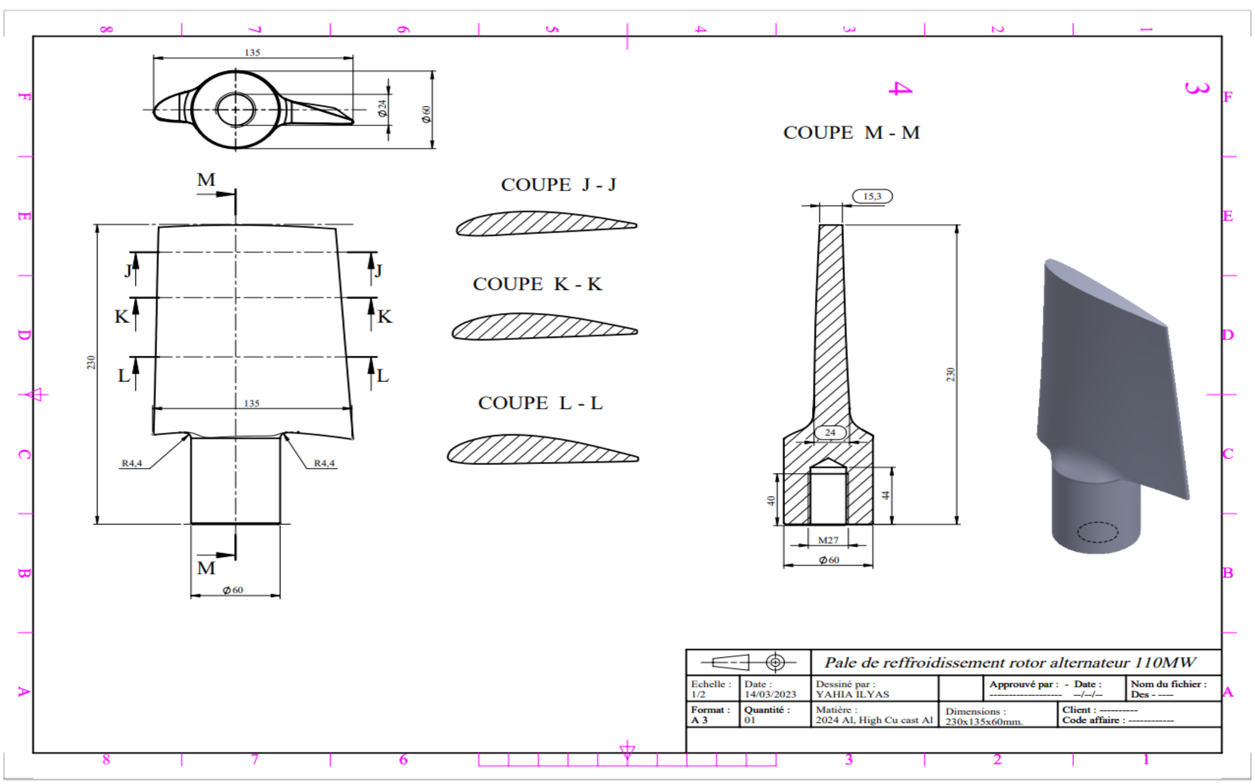


Figure III.15 : Manufacturing document for cooling blade.

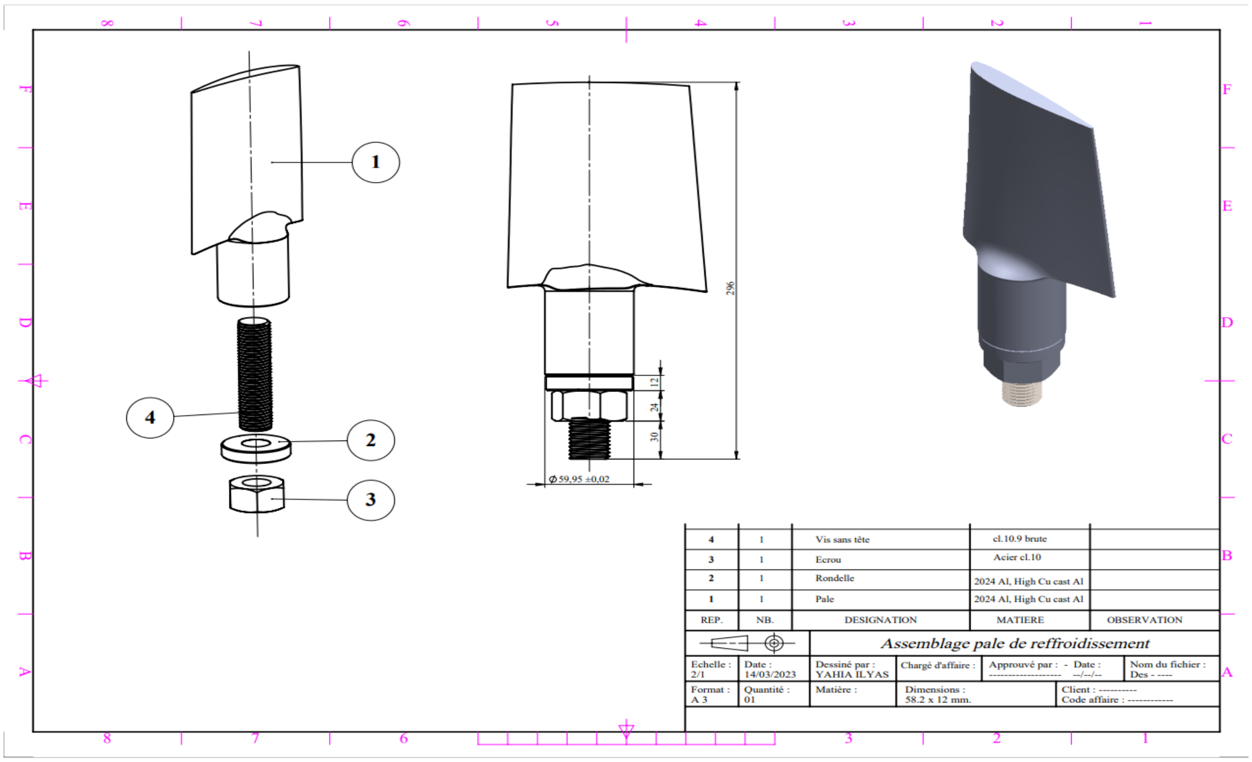


Figure III.16 : Manufacturing document for rotary generator cooling blade assembly.

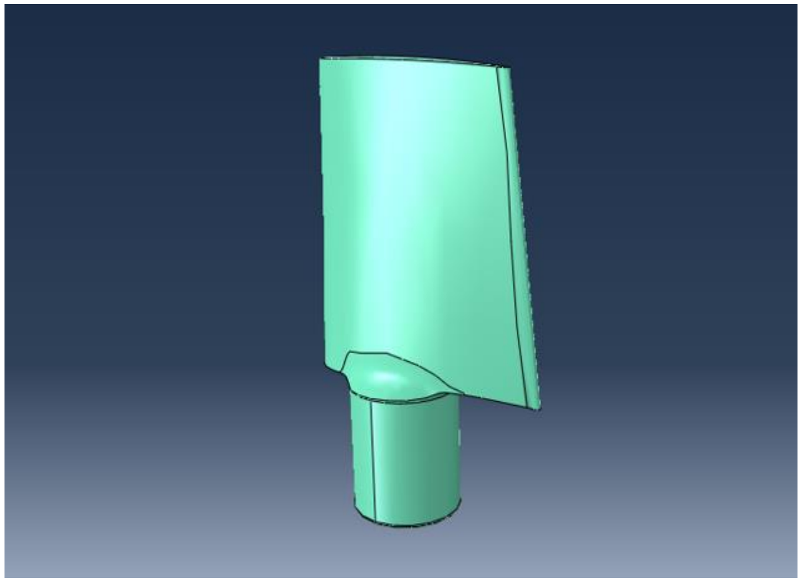
III.4.8. Simulation :

Using the Abaqus program, in this step we will simulate the cooling blade and apply the force applied to it while it cools the rotary generator. We will illustrate this process through pictures accompanied by annotations.

The centrifugal force applied to the cooling blade of the rotary generator can be calculated using the formula F = m * r * w^2 where F is the centrifugal force in newtons, m is the mass of the blade in kilograms, r is the distance between the center of rotation and the blade in meters and w is the angular velocity of the blade in radians per second. We can calculate that the centrifugal force applied to the cooling blade is :

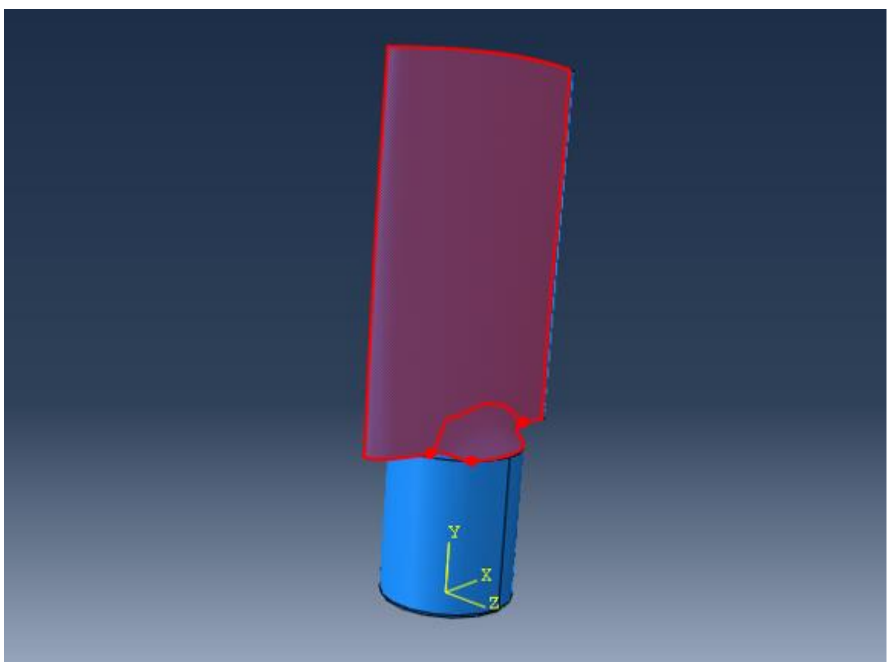
- The mass of the blade is 1.423 kg.
- The distance between the center of rotation and the blade is 0.575 m.
- The length of the blade is 0.296 m.
- The angular velocity of the blade is 314.16 rad/s (3000 revolutions per minute).

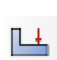
So, F = m * r * w^2 = 1.423 * 0.575 * (314.16)^2 = **80755.95N**

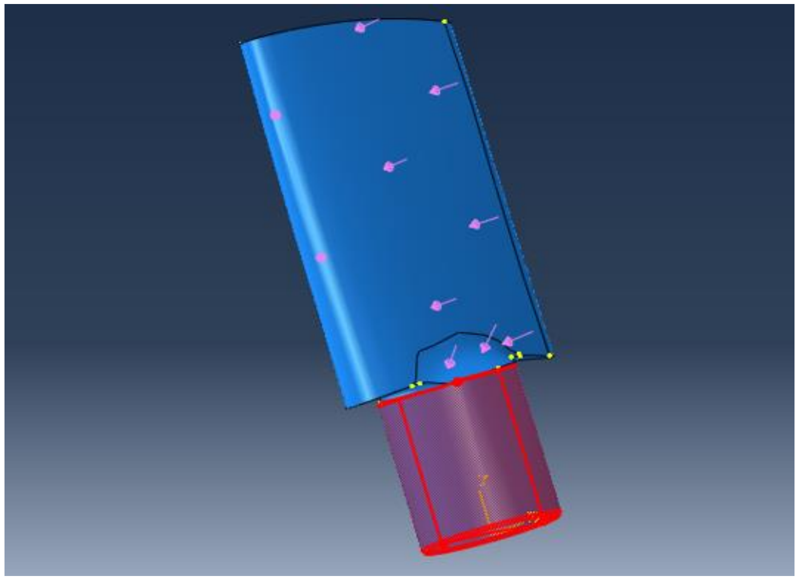


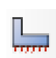
- Open the cooling blade file (STEP) using the Abaqus program.

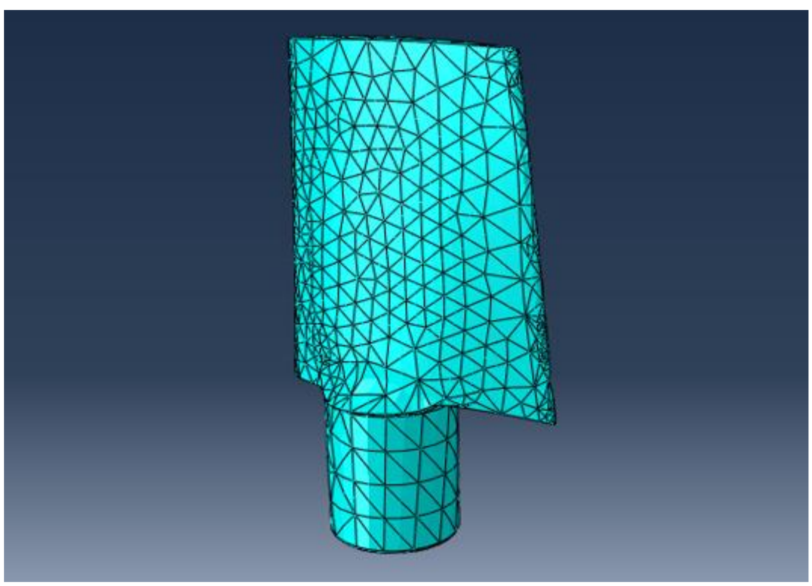
- Click on the Property and we enter the information E=73e6 , ύ=0.33



- Click on the Create load box  and we choose the area to which the force is applied and we enter its value 80755.95N.



- Click on the Create Boundary Condition box  and we choose the fixed area .



-Click on the Mesh box and we enter the information and we choose to divide the elements by 16

- Click on the Job box and we run the simulation.

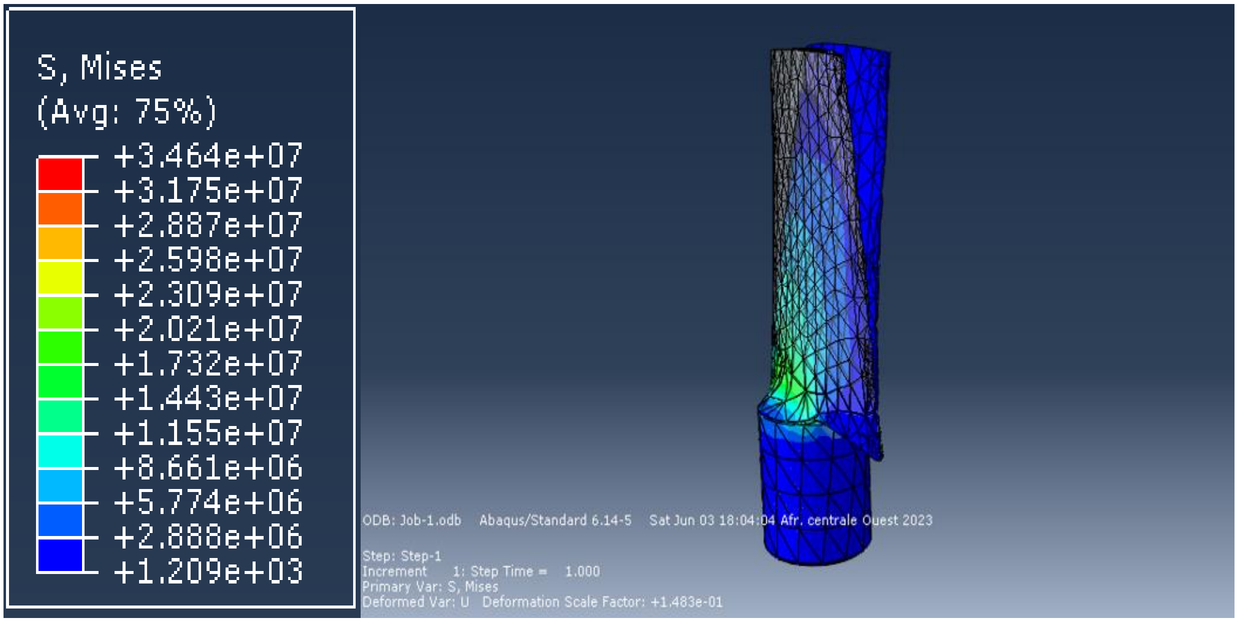


Figure III.17 : Simulation and application of force on a cooling blade using abaqus.

III.4.9. 3D model comparison with that of MEI :

Comparing 3D models refers to the process of analyzing and evaluating the differences or similarities between two or more 3D models. In this context, comparison involves comparing a 3D model with an original MEI model. For the comparison, we will use the Solidworks program.

MEI, in this case, refer to a company, a manufacturer, or an organization that has created or provided a specific 3D model. The purpose of comparing the 3D model with that of MEI could vary, such as quality control, accuracy assessment, design validation, or verification of compliance with certain standards or specifications.

By comparing the 3D model with that of MEI, you can assess the fidelity, accuracy, and compliance of the model you are working with. This comparison helps ensure that the model meets the desired specifications, standards, or design requirements, and enables informed decision-making regarding its use or further modifications. We will illustrate this comparison with pictures from different sides.

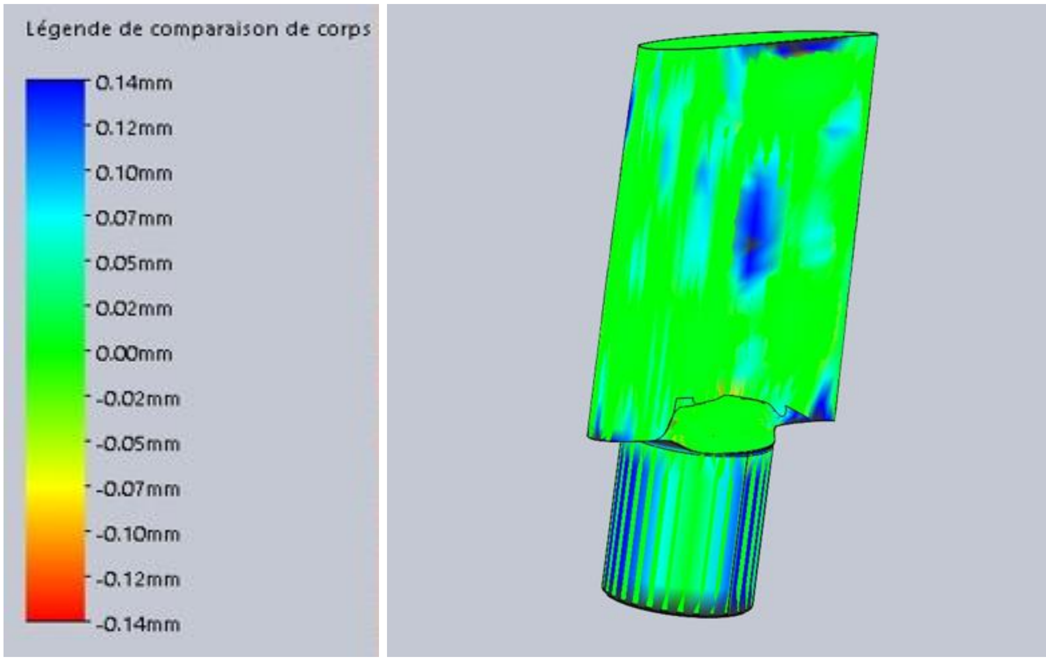


Figure III.18 : Comparison from the first perspective using solidworks.

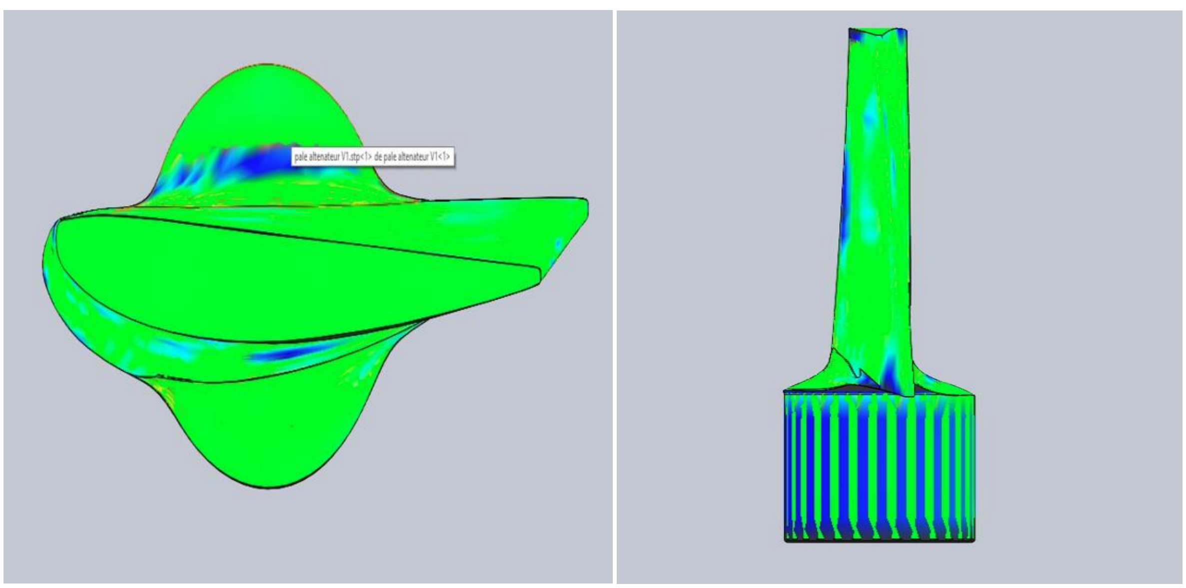


Figure III.19 : Comparison from the second and third perspectives using solidworks.

III.5. Conclusion :

In conclusion, this chapter has provided a comprehensive overview of the design modeling process for a cooling blade. We started by emphasizing the complexity of the process and the need for a deep understanding of various software tools and technologies.

We explored the fundamental software tools required for this process. And we delved into the cooling blade design modeling process itself. This process encompasses several key steps, including the creation of a detailed 3D model using Solidworks and Geomagic Design X, the simulation of performance using Abaqus, and the comparison of the final design to the company's original design. By following this process, engineers can ensure the accuracy and effectiveness of the cooling blade's design, leading to optimized performance and enhanced efficiency.

In summary, this chapter has shed light on the intricate and multi-step nature of the cooling blade design modeling process. By leveraging software tools, such as Solidworks, Geomagic Design X, and Abaqus, alongside the powerful 3D scanner, engineers can create precise models, simulate performance, and refine designs. This comprehensive approach ultimately contributes to the development of efficient and high-performance cooling blades in various industrial applications.

General Conclusion

General conclusion :

In conclusion,This thesis has specifically focused on the application of modeling in the design of rotary generator cooling blades, which play a crucial role in the efficient operation of rotary generators used in diverse applications like power plants. By exploring the design considerations, existing methodologies, and challenges associated with cooling blade design, this research contributes to enhancing the overall performance and reliability of these generators.

Overall, the research presented in this thesis highlights the importance of modeling in mechanical engineering and its potential for driving innovation and efficiency in product development. By continually refining and advancing modeling techniques, engineers can continue to push the boundaries of what is possible in designing mechanical parts and systems, contributing to the progress and advancement of modern society.

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Résume :

Dans cette thèse, nous avons mené une étude théorique sur la modélisation de la conception des pièces mécaniques, et une pièce de forme complexe (Pale de refroidissement du générateur rotatif) a été sélectionnée, au moyen du puissant scanner 3D Steinbishler, et ce travail a été réalisée dans la Société de Maintenance des Equipements Industriels (Sonelgaz à M'sila). Nous utilisons les données résultantes pour traiter le (nuage de points) et nous utilisons pour cela le programme Geomagic Design X. Enfin, la conception a été réalisée dans le programme Solidworks, et les simulations ont été réalisées dans le programme Abaqus. Par conséquent, en suivant simplement cette méthode et en observant toutes les étapes, nous aurons des résultats très satisfaisants par rapport à la pièce d'origine.

Mots-clés : Modélisation de la conception ; Pièce de forme complexe ; Nuage de points ; Simulations.

الملخص :

في هذه المذكرة قمنا بدراسة نظرية حول نمذجة تصميم القطع الميكانيكية , و لقد تم إختيار قطعة ذات شكل معقد (شفرة تبريد للمولد الدوار) , عن طريق الماسح الضوئي ثلاثي الأبعاد القوي Steinbishler , و هذا العمل تم إنجازه في شركة صيانة التجهيزات الصناعية (سونلغاز بالمسيلة). المعطيات الناتجة نستعملها من أجل معالجة (السحابة النقطية) و نستعمل لذلك برنامج Geomagic Design X . و في الأخير تم إنجاز التصميم في برنامج Solidworks و المحاكات في برنامج Abaqus . لذلك، بمجرد اتباع هذه الطريقة ومراعاة جميع المراحل، ستكون لدينا نتائج مرضية جداً مقارنةً بالقطعة الأصلية.

كلمات مفتاحية : نمذجة التصميم, قطعة ذات شكل معقد, السحابة النقطية, المحاكات.

Abstract :

In this thesis, we have conducted a theoretical study on modeling the design of mechanical parts, and a piece with a complex shape (cooling blade for a rotary generator) has been selected, by means of the powerful Steinbishler 3D scanner, and this work has been done in the Industrial Equipment Maintenance Company (Sonelgaz in M'sila) . We use the resulting data to process the (point cloud) and we use the Geomagic Design X program for that. Finally, the design was done in the Solidworks program, and the simulations were done in the Abaqus program. Therefore, by just following this method and observing all the stages, we will have very satisfactory results compared to the original piece.

Keywords : Modeling the design; Piece of complex shape; Point cloud; Simulations.