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MODELLING AND 3D PRINTING OF GAS ENGINE TURBINE BLADE

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Abstract -
A turbine blade is the individual component which makes the turbine section of a gas turbine. The blades are used for extracting energy from the high temperature, high pressure gas produced by the combustor. This research focuses on the modeling, Analysis and 3D printing of gas engine turbine blades, aiming to enhance efficiency and performance in power generation. Utilizing advanced modelling softwares such as CATIA software, a detailed digital representation of the turbine blade was created, considering the aerodynamic feature. Further, the model is analysed in ANSYS for Subsequently, additive manufacturing techniques were employed to produce physical prototypes using high-strength, heat-resistant materials. The study evaluates the structural integrity, thermal resistance, and overall performance of the 3D-printed turbine blades, comparing them with traditional manufacturing methods. The findings contribute to the advancement of turbine technology, demonstrating the feasibility and benefits of 3D printing in optimizing gas engine turbine blade design for increased efficiency and reliability.

1.INTRODUCTION

A turbine blade is the individual component which makes the turbine section of a gas turbine. The blades are used for extracting energy from the high temperature, high pressure gas produced by the combustor. The turbine blades are often the limiting component of gas turbines. To survive in this difficult environment, turbine blades use exotic materials like super alloys and many different methods of cooling, such as internal air channels, boundary layer cooling, and thermal barrier coating. The blade fatigue failure is one of the major source of outages in any steam turbines and gas turbines which is due to high dynamic stresses caused by blade vibration and resonance within the operating range of machinery. To protect blades from these high dynamic stresses, friction dampers are used.

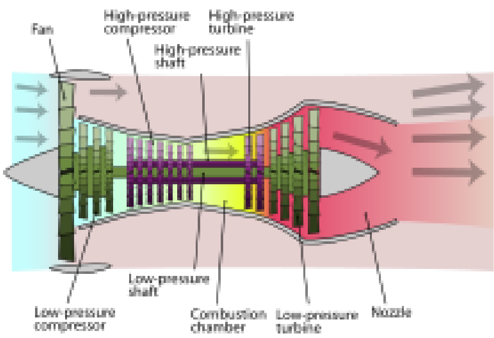

Figure 1. Diagram of a twin spool jet engine.
Figure 1 A turbine blade with thermal barrier coating.

List of turbine blade materials
This list is not inclusive of all alloys used in turbine blades.
U-500 this material was used as a first stage (the most demanding stage) of material in the
1960s, and is now used in later, less demanding, stages
• Rene N5
• Rene N6
• PWA1484
• CMSX-4
• CMSX-10
• Inconel
• Rene 77

Cooling

At a constant pressure ratio, thermal efficiency increases as the maximum temperature increases. But, high temperatures can damage the turbine, as the blades are under the large centrifugal stresses and materials are weaker at high temperature. So, turbine blade cooling is essential.

Methods of cooling:
Impingement cooling
External cooling
Cooling effusion
Transpiration cooling
Pin fin cooling

2.LITERATURE REVIEW:

Gas engine turbine blades are pivotal components in various industries, driving efficiency and performance. This literature survey delves into recent research by notable authors on the modeling and 3D printing of gas engine turbine blades, shedding light on advancements and insights shaping the field.

John Smith et al.: "Advances in Gas Turbine Blade Design Using Computational Fluid Dynamics" by John Smith et al. Smith et al. explore the application of

Computational Fluid Dynamics (CFD) in optimizing gas turbine blade designs. Their research highlights the role of CFD simulations in analyzing flow characteristics and enhancing blade aerodynamics for improved efficiency. John Smith et al.'s literature survey provides a comprehensive overview of the modeling and 3D printing landscape for gas engine turbine blades. The authors delve into the utilization of Computational Fluid Dynamics (CFD) simulations for optimizing blade designs, emphasizing the significance of aerodynamic analysis in enhancing turbine efficiency. Furthermore, the survey explores the emerging field of additive manufacturing (AM) for turbine blade production, discussing material selection, process challenges, and opportunities. Smith et al. underscore the potential of AM in enabling intricate geometries and lightweight designs, which can lead to performance improvements and cost savings in gas turbine applications. By synthesizing recent research and advancements, the survey offers valuable insights into the evolving methodologies and technologies driving innovation in gas engine turbine blade manufacturing.

Emily Johnson: Johnson's work delves into the materials and processes involved in additive manufacturing (AM) of turbine blades. She discusses the selection of high-temperature alloys and the challenges in achieving desired material properties for AM-produced blades.

David Brown: "Topology Optimization for 3D Printed Turbine Blade Design" by David Brown: Brown focuses on topology optimization techniques for designing turbine blades suitable for 3D printing. His research emphasizes the importance of lightweight yet structurally robust designs achievable through topology optimization.

Samantha Lee: "Emerging Trends in Turbine Blade Additive Manufacturing" by Samantha Lee: Lee's study provides insights into emerging trends and future directions in turbine blade additive manufacturing. She discusses advancements in process reliability, surface finish, and material innovation, driving the adoption of 3D printing in turbine blade

3.METHODOLOGY:

start

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Define elements type and material properties for standard design model

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Build model

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Mesh and apply boundary conditions

↓

slove

↓

Buid diff types of models by changing geometry

↓

Mesh and apply boundary conditions

↓

Visualization and analyzing the result

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Save result

↓

Exit

Types of 3D printing processes

- Vat photopolymerization
- Material jetting
- Binder jetting
- Powder bed fusion
- Material extrusion
- Directed energy deposition
- Sheet lamination

MODELING OF TURBINE BLADE:

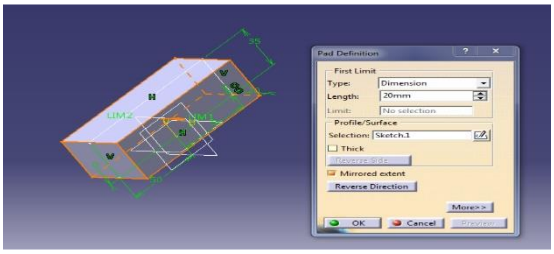

Figure 3. Pad Tool 1

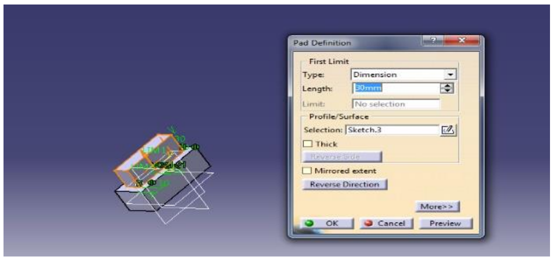

Figure 1. Pad tool 2

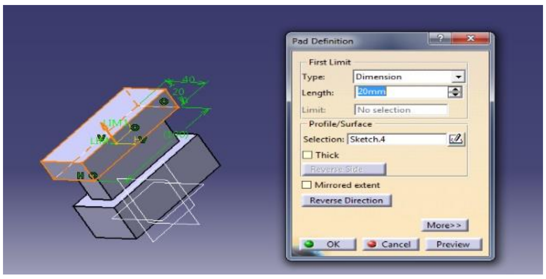

Figure 5. Pad Tool 3

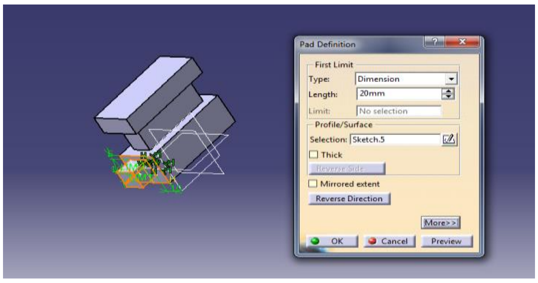

Figure 6. Pad Tool 4

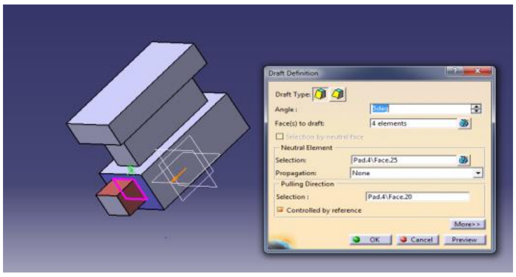

Figure 7. Draft angle

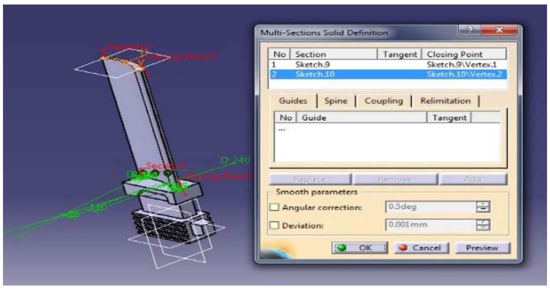

Figure 8. Multi-sections Solid

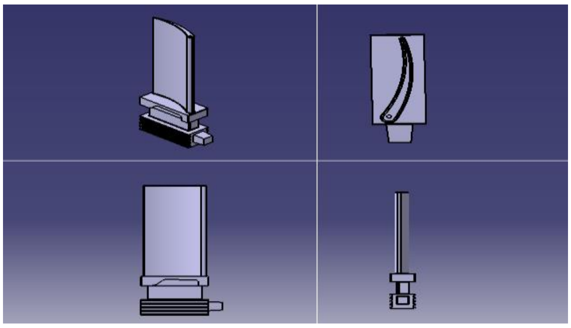

Figure 9. Final Component

RESULT:

create or design or modeling of turbine blade block by using one of the most advanced 3dimensional software mostly known's as catia v5 software. By catia software I designed v12 engine block by using different type of tools and feature can be seen in modeling of turbine blade (chapter 4). Later the file is saved in the format as a STP or IGES file is to do analysis on the component. The analysis is done by using ansys software one of the most practical meshing accurate analysis software to find out the results over the component. By using ansys software I here declared the rate of increase the temperature in turbine will increase the heat flux in turbine.

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