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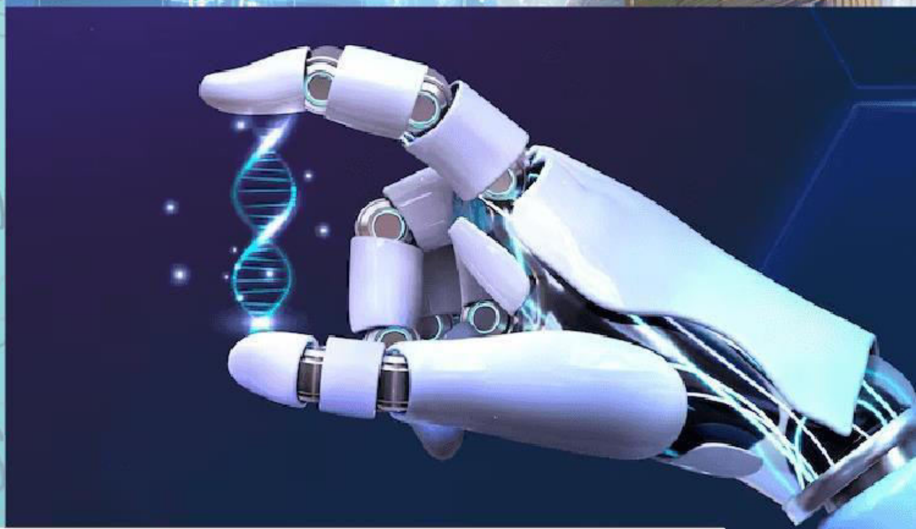

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Modelling and Thermal Analysis of Gas Turbine Rotor Blade

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ABSTRACT: A Gas turbine rotor blade is the individual Component which make up the turbine part of a gas turbine. The turbine is a rotary device which uses mechanical power generating power of flowing fluid and convert it into useful work.

By Optimizing the blade geometry and material Selection, this study aims to enhance the durability and good efficiency of gas turbine blades, reducing the Thermal distortion and improve overall turbine performance.

In this project, CATIA V5 R20 is used for the modelling of turbine blade and to analyze various will be material, ANSYS will be used and results tabulated.

I. INTRODUCTION

GAS TURBINE BLADE:

A turbine blade is the individual component which makes up the turbine section of a gas turbine. The blades are responsible 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 often use exotic materials like super alloys and many different methods of cooling, such as internal air channels, boundary layer cooling, and thermal barrier coatings. 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.

Blades of wind turbines and water turbines are designed to operate in different conditions, which typically involve lower rotational speeds and temperatures.

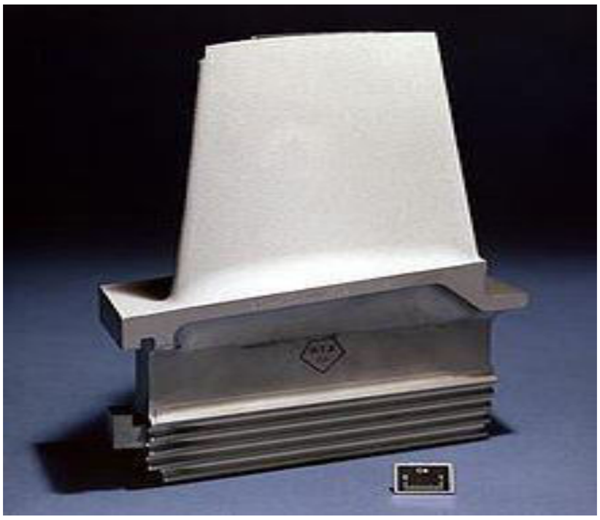

Fig 1.1 A Turbine Blade with Thermal Barrier Coating

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II. LITERATURE SURVEY

Soo-Yong Cho [1] Heat transfer analysis of gas turbine blade is carried out with different models consisting of blade with without holes and blade with varying number of cooling holes. It is found that total heat transfer rate is maximum and the temperature of the blade leading edge is minimum for the blade consisting of 13 holes. The thermal and structural analysis is studied for two different materials constructions that is Chromium steel and Inconel718. By observing the graphs the thermal flux is maximum of Inconel718 blade with consisting of 13 number of holes, and the induced von misses stress and strain are within allowable limits. It is found that inconel718 is better than Chromium steel.

John.V, T.Ramakrishna [2] As turbine blade cooling is studied for two different materials of constructions that is N 155 &Inconnel 718. It is found that Inconnel 718 has better thermal properties as the blade temperatures and thermal stresses induced are lesser. The provision of cooling passages in the blades is found to alleviate the problem of high temperatures and thermal stresses. It is observed that as the no. of holes increases the temperature distribution increase. The structural analysis is carried out after the thermal analysis in SOLID WORKS SIMULATION TOOL. It is observed that blade with 10 holes has showing more stresses than the remaining blades. Finally the blade with 9 holes has giving optimum performance for prescribed loading conditions with average temperature of 514.1K at the trailing edge and von misses stresses as 17.7 Mpa.

B. Deepanraj [3] The finite element analysis for structural and thermal analysis of gas turbine rotor blade is carried out using. Solid 95 element. The temperature has a significant effect on the overall turbine blades. Maximum elongations and temperatures are observed at the blade tip section and minimum elongation and temperature variations at the root of the blade. Maximum stresses and strains are observed at the root of the turbine blade and upper surface along the blade roots three different materials of construction i.e., N-155, Inconel It is seen from above results both the materials are giving the considerable results; finally the conclusion can be one on the basis of the cost and the availability of the materials.

P.V.Krishnakanth [4] The temperature has a significant effect on the von Mises stress in the turbine blade. Maximum elongation and temperatures are observed at the blade tip section and minimum elongation and temperature variations at the root of the blade. The thermal stresses are predominant in the analysis when compared to the Pressure and Centrifugal forces. Deformations gradually increase along the blade length from root to the tip portion of the blade.

Je-Chin Han [5] Film cooling is widely used to protect modern gas turbine blades and vanes from the ever-increasing inlet temperatures. Film cooling involves a very complex turbulent flow-field, the characterization of which is necessary for reliable and economical design. Several experimental studies have focused on gas turbine blade, vane and end-wall film cooling over the past few decades. Measurements of heat transfer coefficients, film cooling effectiveness values and heat flux ratios using several different experimental methods have been reported. The emphasis of this current review is on the Pressure Sensitive Paint (PSP) mass transfer analogy to determine the film cooling effectiveness.

Lalit Dhamecha [6] Gas turbine play a vital role in the today's industrialized society, and as the demand for power increase, the power output and thermal efficiency of gas turbine must also increase. One method of increasing both the power output and thermal efficiency of the engine is to increase the temperature of the gas entering the turbine. In the advanced gas turbine, the inlet temperature of around 1500°C is used; however, this temperature exceeds the melting temperature of the metal aerofoils. Therefore, along with high temperature material development, a refined cooling system must be developed for continuous safe operation of gas turbines with high performance.

L.Umamaheswararao [7] the first stage rotor blade of a gas turbine has been analysed for structural, thermal analysis using ANSYS (Finite Element Analysis Software). The material of the blade was specified as INCONEL 718. The thermal boundary conditions on the rotor blade are taken from the reference. The temperature distribution across the blade is obtained. The maximum stress up to which the blade can withstand is known and the stress distributions across the blade are obtained accordingly. The obtained results are compared with N-155, Mild Steel and the most suitable material is discussed. In final the actual fir tree model blade root compared with I-section model blade root, results are tabulated, and it is observed that stress distribution less in fir tree model that the I-section model.

Amjed Ahmed Jasim AL-Luhaibi [8] Performance of a gas turbine is mainly depending on various parameters e.g. ambient temperature, compressor pressure ratio, turbine inlet temperature etc. The most important parameter to increase

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the life of the turbine blade is the cooling of the blade, which is necessary after reaching a certain temperature of the gases passing through the blades.

Various types of cooling models are available for a turbine blade cooling. The power output of a gas turbine depends on the mass flow rate through it. This is precisely the reason why on hot days, when air is less dense, power output falls off.

III. METHODOLOGY

The thermal analysis of the gas turbine rotor blade was carried out using a combination of Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA). A 3D model of the rotor blade was developed using CAD software and imported into ANSYS Workbench. Steady-state thermal simulations were performed to evaluate temperature distribution across the blade surface, considering convection and radiation from hot combustion gases. Material properties such as thermal conductivity, specific heat, and temperature-dependent behavior of nickel-based superalloys were incorporated. Internal cooling features, including serpentine channels and film cooling holes, were modeled to assess cooling effectiveness. The thermal results from CFD simulations were then coupled with structural analysis to evaluate thermal stresses and potential deformation. Mesh independence tests and validation against existing experimental data ensured the accuracy of the simulation. This integrated approach enabled a comprehensive assessment of the blade's thermal performance under realistic operating conditions.

Problem identification
↕
Selection of material
↕
Creating a 3D model in SOLIDWORKS
↕
Analysing the model
↕
Comparing the results

INTRODUCTION OF CATIA V5R20

CATIA is the leading solution for product success. It addresses all manufacturing organizations. CATIA can be applied to a wide variety of industries, from aerospace, automotive, and industrial machinery, to electronics, shipbuilding, plant design, and consumer goods. Today, CATIA is used to design anything from an airplane to jewelry and clothing. With the power and functional range to address the complete product development process, CATIA supports product engineering, from initial specification to product-in-service, in a fully-integrated manner. It facilitates reuse of product design knowledge and shortens development cycles, helping enterprises to accelerate their response to market needs.
CatiaV5R20 is an interactive Computer- Aided Design and Computer Aided Manufacturing system. The CAD functions automate the normal engineering, design and drafting capabilities found in today's manufacturing companies. The CAM functions provide NC programming for modern machine tools using the CatiaV5 R16 design model to describe the finished part. CatiaV5R20 functions are divided into "applications" of common capabilities. These applications are supported by a prerequisite application called "CatiaV5R20 Gateway".

CatiaV5R20 is fully three dimensional, double precision system that allows to accurately describing almost any geometric shape. By combining these shapes, one can design, analyze, and create drawings of products.

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MODELLING OF Gas TURBINE ROTOR BLADES

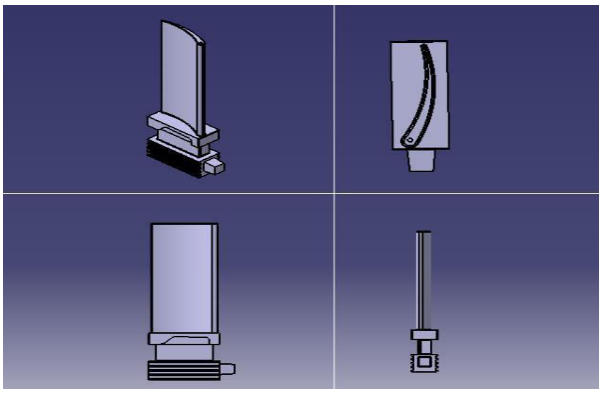

Fig 2 Design of Turbine Blades

INRODUCTION OF FEA:

The company was founded in 1970 by Dr. John A. Swanson as Swanson Analysis Systems, Inc. SASI. Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static (stationary), dynamic (moving) and heat transfer (thermal) problems. SASI developed its business in parallel with the growth in computer technology and engineering needs. The company grew by 10 percent to 20 percent each year, and in 1994 it was sold to TA Associates. The new owners took SASI's leading software, called ANSYS®, as their flagship product and designated ANSYS, Inc. as the new company name.

ANSYS, Inc. is an engineering simulation software (computer-aided engineering, or CAE) developer that is headquartered south of Pittsburgh in the Southpointe business park in Cecil Township, Pennsylvania, United States. ANSYS was listed on the NASDAQ stock exchange in 1996. In late 2011, ANSYS received the highest possible score on its Smart Select Composite Ratings according to Investor's Business Daily The organization reinvests 15 percent of its revenues each year into research to continually refine the software.

ANSYS offers engineering simulation solution sets in engineering simulation that a design process requires. Companies in a wide variety of industries use ANSYS software. The tools put a virtual product through a rigorous testing procedure (such as crashing a car into a brick wall, or running for several years on a tarmac road) before it becomes a physical object.

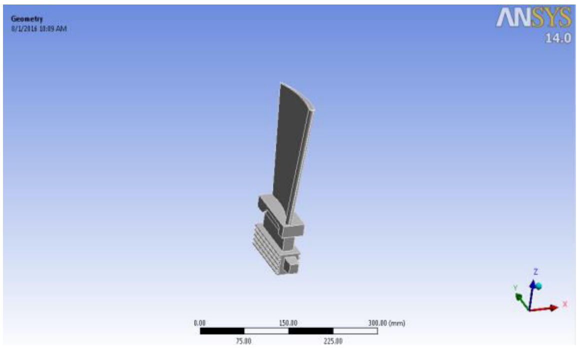

Fig 3 Model with Ansys tools

Static Analysis Of Turbine Blade:

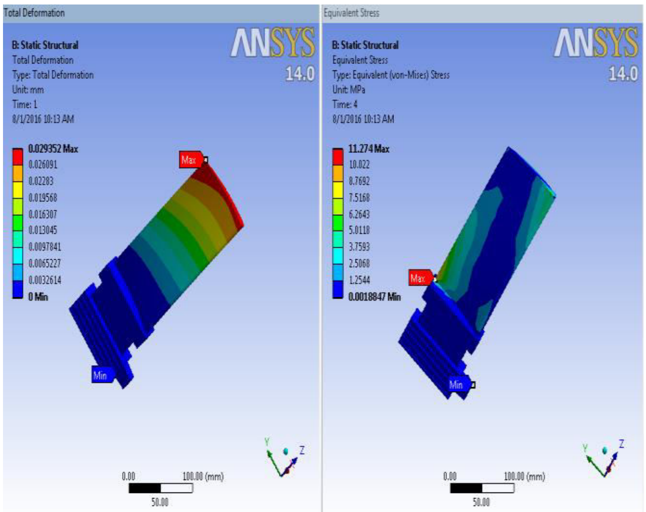

Fig 4 Result window

IV. CONCLUSION

In this project, i here 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 to do analysis on the component.

The analysis is done by 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 blade.

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