ANALYSIS OF GAS TURBINE BLADES THROUGH MODELLING

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Abstract:

Turbine blade is the individual component which makes up the turbine part of a gas turbine. The turbine is a mechanical power generating rotary device which uses power of flowing fluid and converts it into useful work. The aim of the project is to design a turbine blade using 3D modeling software CATIA by using the CMM point data available. CMM data taken from coordinate measuring machine. This project involve structural analysis by applying the angular velocities for various materials in evaluating stresses developed and mode shapes of the blade. CATIA is the standard tool in 3D product design, featuring industry leading productivity tool that promote best practices in design. Structural analysis performed on the blade using commercial software ANSYS.

Keywords: *Turbine Blade; Structural Analysis, CATIA.*

Introduction:

The gas turbine, in its most common form, is a rotary heat engine that operates by compressing air from the atmosphere, increasing gas temperature through constant-pressure combustion of the fuel in the air, expanding hot gases, and finally releasing the gases into the atmosphere, all in continuous process. In terms of working medium and internal combustion, it is similar to petrol and diesel engines, but in terms steady flow of the working medium, it is similar to stream turbines.

There are few researches have been conducted in numerical analysis to optimize the turbine disc profile design and improve turbine systematic performance. The cooling conditions should be assumed to the turbine wheel when analyze the parametric effects and determine the superposed mechanical and thermal stresses. If the system is not properly designed, the turbine components including wheel disc will deform beyond the material yield strength due to high speed and temperature conditions. The high speed rotation of turbine wheel must be maintained at a temperature a little higher than surrounding atmospheric temperature to keep turbine wheel from material brittle fracture. This is the technique of hot spinning used to analyze the gas turbine wheel rotating in high temperatures. The low cycle fatigue life of turbine wheel can be increased by adding mass to the turbine wheel area so that the tangential stress can be reduced in wheel. Since it also adds weight to the disc rim, this process is not a good way to lower the combined stresses in turbine wheel. The hot spinning process can uniformly heat the turbine disk to a predefined high temperature to provide proper thermal gradient between turbine disk and rim through decreasing the rim temperature by cooling method. As the turbine wheel rim is cooled to a specific temperature, a thermal gradient is generated between the wheel disc and rim causing the compressive residual stress produced in turbine wheel rim. The hot spinning methodology can cost-effectively increase the low cyclic fatigue life, well implement the processing equipment, easily add predefined residual stress to the turbine wheel, and add no additional material weight in the process.

Development of coatings for protection of gas turbine blades

Coatings are routinely used to anchor high temperature air upset sections in forefront gas turbines with ultimate objective to improve ir insurance from oxidation, utilization and breaking down. Many covering syses and declaration procedures are curently passed on to improve surfaces of superalloys with segments, for instance, aluminum, chromium, platinum, silicon, etc which redesign ir security from high temperature debasement frames. Nevertheless, disregarding fortunate execution record of coatings, for instance, those of MCrAlY overlay type, look is continuing for less unpredictable, more affordable, elective covering strategies and for upgraded covering materials. In this paper a graph depiction is displayed of three elective covering procedures that offer noteworthy potential for keeping overlays. first relies upon use of heartbeat weight substance vapor affirmation of aluminum, etc (1) into surface of a pre-kept plasma showered layer both to infill surface-related deformations and furrmore to survey structure of outer layers. or on the other hand two procedures are Sputter Ion Plating (SIP) and Occluded Plating. A wide extent of coatings structures has been spared by se techniques on cast nickel superalloy test pieces and all the more puzzling aerofoil sections. Results are presented of ir execution under oxidation, creep-burst and warm weariness tests. Examination is in like manner made of ir direct under fast oxidation and disintegration tests finished in gas turbine test framework type rigs for lengths of up to 500 hours. presents usages of an arrangement of guarded coatings for parts of a flying machine engine. In front bit of engine, affirmed cool portion, checking fan and blower, scratched zone and separating safe coatings and seals are commonly utilized. In present day motors, such nippy locale parts as fan sharp edges, blower edges and Composites, titanium-aluminum amalgams, titanium, and heat-resistant steels are used to make impellers. Warm block coatings (TBCs) and high-temperature seal coatings are employed in hot piece engine connects chamber zone turbine. Parts with high operating temperatures necessitate use super composites, primarily nickel-based blends. Turbine sharp edges are passed on by eir directional or monocrystalline developing at moment. They were first manufactured using plastically worked materials, but today and into not all inaccessible materials, they are passed on by eir directional or monocrystalline developing. At the same time, turbine is being overhauled sharp edge worsens progress in sparkle safe covering and warm check covering headways happened. present article means to portray right at present related nickel-based blends and to demonstrate writers' own special examination on scratched zone and disintegrating safe coatings, dissipating aluminide coatings and warm limit coatings.

Literature review

Priyanka Singh (2016) In a gas turbine engine, the turbine blade operated higher temperature then the melting point of the blade material. Cooling of gas turbine blades is a major consideration for continuous safe operation of gas turbines with high performance. Several methods have been suggested for the cooling of blades and one such technique is to have radial holes to pass high velocity cooling air along the blade span. In the present work CFD analysis is used to examine the heat transfer analysis of gas turbine with six different model consisting of 5,9&13 inline one row of holes and compared with 9&13 model in staggered holes arranged in the three rows and developed a new model with 14 holes in the staggered arrangement. The prediction is commonly used CFD software FLUENT (a turbulence realizable k-e model with enhanced wall treatment).

Vasarla Satish et al (2019) Gas Turbine is an internal combustion engine that uses air as the working fluid. In the design of the blades is to find the frequency at which the resonance exists. Prototype building and testing of the blades is highly expensive and is a time consuming process. Remedy to avoid prototype building is the Finite Element Analysis. But Finite Element Analysis throws a challenge in terms of the size of the model and analysis time. To build a 360 degree Rotor blade model in Finite Element Analysis with the required degree of accuracy and analysis is very difficult as it involves high configuration systems. Moreover, the time consumption for the analysis of a 360 degree model is high. To overcome this, in the present analysis, a concept called as "Cyclic symmetry Analysis " is utilized.

Binita Kundu (2021) Abstract In turbomachinery, the turbine blades play an important role. While operating these blades rotate at high speed and as a result, are subjected to high centrifugal force. The gas turbine transforms the natural gas into mechanical energy, and then the mechanical energy generated by the turbine exit shaft is then transferred through a gearbox to the generator shaft. Due to high rotation speed, the centrifugal stresses act on the blade. Then, due to the presence of different blade material, along with the temperature dependency, thermal stress and deformation are developed. So, this paper is a review of various factors affecting the turbine blade.

ANALYSIS OF RESULTS:

The findings analysis gas turbine blade for original profile and transient thermal analysis are discussed in this chapter. Also, by comparing results, graphs were explained.

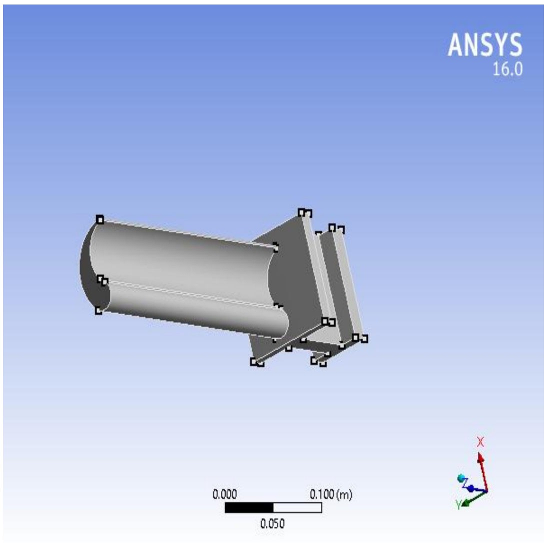

TABLE 1

Unit system	Metric (m,kg,N,s,V,A)Degrees rad/s Celsius
Angle	Degrees
Ratational Velocity	rad/s
Temperature	Celsius

DESIGN AND ANALYSIS OF BLADE

Airfoil profile is based on the performance of the compressor. Information focuses are accommodated the cross area of the Airfoil. Information focuses are then associated by utilizing the splines and after that joined to shape the zones in Ansys.

Following are the data points considered for the airfoil profile.

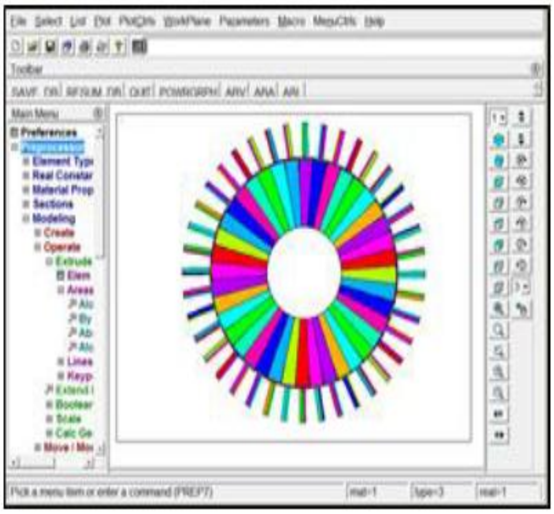

Figure: Solid Blade Creation

Base of the Airfoil is then extruded in the other direction to create rotor wheel so that a cyclic symmetry sector with a sector angle of 9 degree. Cyclic sector is then copied 40 times to form a complete stage of Rotor as shown in the below figure

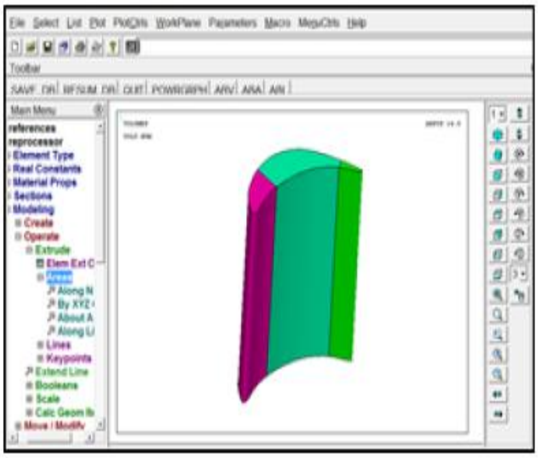

Figure: Rotor Wheel with Blades

CONCLUSION

From the Simulation study of the blade model without thermal barrier coating, it is clear that the coating is essential for the gas turbine blade to work efficiently under high temperature. We have carried out an analysis of the blade model with a different coating material. From the static structural analysis, we find that blade coated with Zirconium carbide has lesser induced maximum stress value compared to the other two coating materials. So, it is clear that Zirconium carbide can withstand a higher load compared to the other two materials. From the steady-state thermal analysis, we find that the maximum heat flux value) for the blade model with Zirconium carbide coating is less compared to the other two models. The coating material along with adding strength and thermal resistance to the blade, it should be very light in weight so that the power requirement for the turbine engine should not increase much. So, Zirconium carbide is one of the low-density Ceramic material its best suite alternative for coating of the gas turbine blade.

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