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Full Length Article

Structural and Thermal Analysis of Gas Turbine

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ABSTRACT: A gas turbine is a device designed to convert the heat energy of fuel into useful work, such as mechanical shaft power. The gas turbine in its most common from is a rotary heat engine operating by means of series of processes consisting of air taken from the atmosphere, increase of gas temperature by constant pressure combustion of the fuel, the whole process being continuous. Turbine Blades are the most important components in a gas turbine power plant. A blade can be defined as the medium of transfer of energy from the gases to the turbine rotor. The turbine blades are mainly affected due to static.Also the temperature has significant effect on the blades. Therefore the turbine blades to be analysed for the mechanical andthermal stresses. The turbine blades analysis is carried out using finite element analysis software ANSYS.

Keywords: Gas turbine, structural and thermal analysis,ANSYS.

1 Introduction

A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. A turbine is a turbo machine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor. The gas turbine is the most versatile item of turbo machinery today. It can be used in several different modes in critical industries such as power generation, oil and gas, process plants, aviation, as well domestic and smaller related industries. A gas turbine essentially brings together air that it compresses in itscompressor module, and fuel, that are then ignited. Resulting gases are expanded through a turbine

A separator starter unit is used to provide the first rotor motion, until the turbine's rotation is up to design speed and can keep the entire unit running. The compressor module, combustor module and turbine module connected by one or more shafts are collectively called the gas generator.

1.1 Introduction to gas turbine

Fig 1. Gas Turbine Rotor Blades

Gas turbines are used for power generation. Today, gas turbines are one of the most widely-used power generating technologies. Gas turbines are a type of internal combustion (IC) engine in which burning of an air-fuel mixture produces hot gases that spin a turbine to produce power. It is the production of hot gas during fuel combustion, not the fuel itself that the gives gas turbines the name. Gas turbines can utilize a variety of fuels, including natural gas, fuel oils, and synthetic fuels. Combustion occurs continuously in gas turbines, as opposed to reciprocating IC engines, in which combustion occurs intermittently. Gas turbine engines derive their power from burning fuel in a combustion chamber and using the fast flowing combustion gases to drive a turbine in much the same way as the high pressure steam drives a steam turbine.

2.COMPONENT SELECTION

2.1NICKEL-CHROMIUM ALLOY (N 155)

Ni chrome (Ni Cr, nickel-chrome, chrome-nickel, etc.) generally refers to any alloy of nickel, chromium, and often iron and/or other elements or substances. Ni chrome alloys are typically used in resistance wire. They are also used in some dental restorations (fillings) and in other applications.

Table 1 Properties of N155

Properties	Units	N155
E	Pa	143E09
ρ	Kg/cu m	8249
K	W/m-K	20.0
μ	---	0.344
α	E-06/^{O}C	17.7
C_p	J/Kg K	435
Melting point	^{O}C	1354
Yield stress	MPa	550

2.2 HASTE ALLOY X

Haste alloy is the registered trademark name of Haynes International, Inc. The trademark is applied as the prefix name of a range of twenty-two different highly corrosion-resistant metal alloys, loosely grouped by the metallurgical industry under the material term “super alloys” or “high-performance alloys”.

Table 2 Properties of Haste Alloy X

Properties	Units	Haste alloy X
E	Pa	144E09
P	Kg/cu m	8300
K	W/m-K	25
μ	---	0.348
A	E-06/^{O}C	16
C_p	J/KgK	450
Melting point	^{O}C	1380
Yield stress	MPa	360

2.3 INCONEL 625

oxidation and corrosion resistant materials well suited for service in extreme environments subjected Inconel is a family of austenite nickel-chromium-based super alloys. Inconel alloys are to pressure and heat.

Table 3 properties of Inconel 625

Properties	Units	Inconel625
E	Pa	150 E09
P	Kg/cu m	8400
K	W/m-K	10
μ	---	0.331
A	E-06/^{O}C	15
C_p	J/KgK	410
Melting point	^{O}C	1350
Yield stress	MPa	1030

3.MODELING

3.1 INTRODUCTION TO CAD/CAM :

CAD/CAM is a term which means computer-aided design and computer-aided manufacturing. It is the technology concerned with the use of digital computers to perform certain functions in design and production. This technology is moving in the direction of greater integration of design and manufacturing, two activities which have traditionally been treated as district and separate functions in a production firm. Computer – aided design (CAD) can be defined as the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. In computer-aided design, geometricmodeling is concerned with the computer- compatible mathematical description of the geometry of an object. The mathematical description allows the image of the object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system.

3.2THE DESIGN PROCESS

The process of designing is characterized by six identifiable steps or phase

1. Recognition of need
2. Definition of problem
3. Analysis and optimization
4. Evaluation,Presentation &Synthesis

3.3 A SOLID MODELLING

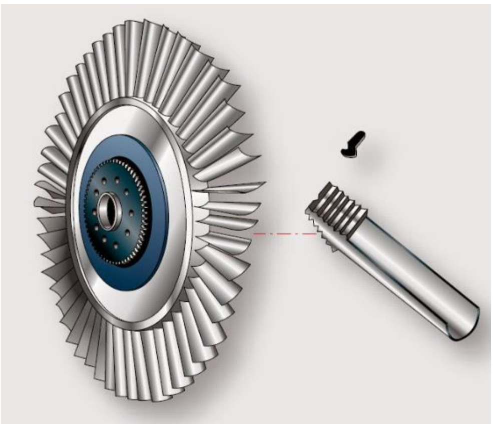

Fig 3. Model in gas turbine

CAD system uses solid model supposed to be the best complete geometric model. All the surface geometry and wireframe are contained in it which are required to describe fully the model's faces and edges. Apart from geometric information, topology of solid models are also conveyed by them. Geometry together are also related by solid modelling. As an example, identification of faces (surfaces) at edges (curves) may be included in topology.

4.ANALYSIS

4.1INTRODUCTION TO FEM

In mathematics, the finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses variation methods (the calculus of variations) to minimize an error function and produce a stable solution. Analogous to the idea that connecting many tiny straight lines can approximate a larger circle, FEM encompasses all the methods for connecting many simple element equations over many small sub domains, named finite elements, to approximate a more complex equation over a larger domain.The subdivision of a whole domain into simpler parts has several advantages:

- Accurate representation of complex geometry
- Inclusion of dissimilar material properties
- Easy representation of the total solution

FEM is best understood from its practical application, known as finite element analysis (FEA). FEA as applied in engineering is a computational tool for performing engineering analysis.

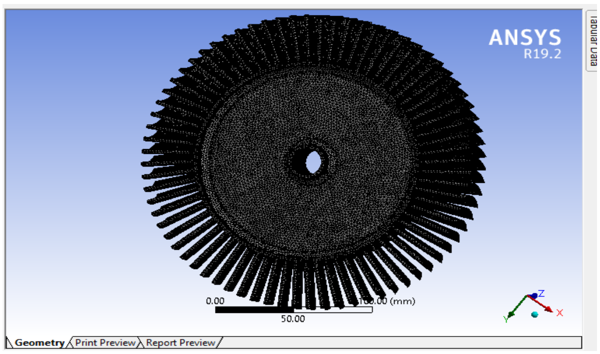

Fig 4. Meshing

FEM solution to the problem at left, involving a cylindrically shaped magnetic shield. The ferromagnetic cylindrical part is shielding the area inside the cylinder by diverting the magnetic field created by the coil (rectangular area on the right).

5.APPLICATION

A variety of specializations under the umbrella of the mechanical engineering discipline(suchas aeronautical, biomechanical, and automotive industries) commonly use integrated FEM in design and development of their products. Several modern FEM packages include specific components such as thermal, electromagnetic,fluid, and structural working environments. In a structural simulation, FEM helps tremendously in producing stiffness and strength visualizations.

6.RESULT

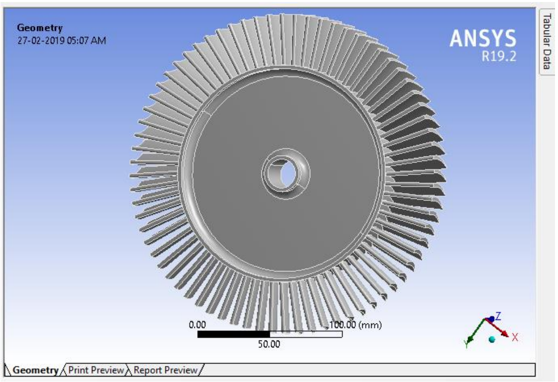

Fig7.1Design

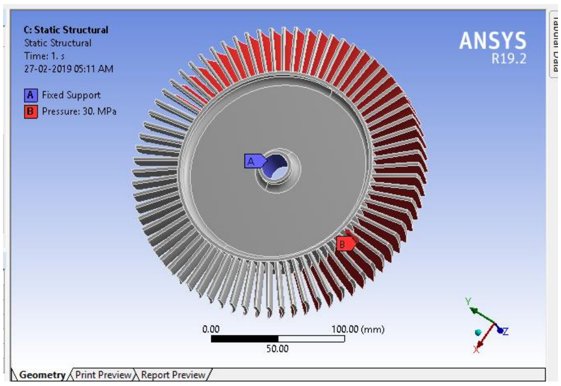

FIG7.2Pressure

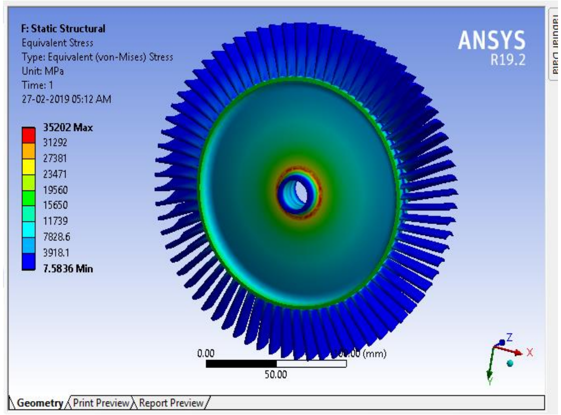

FIG7.3Static structural

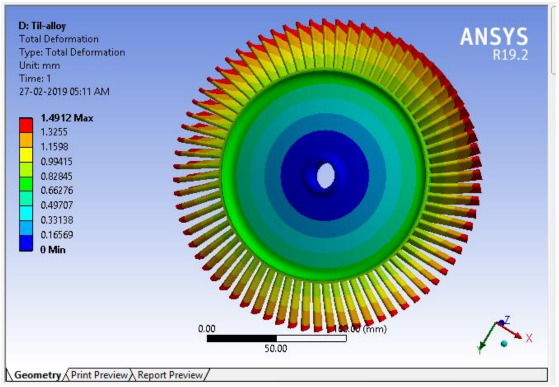

FIG7.4Titanium Alloy

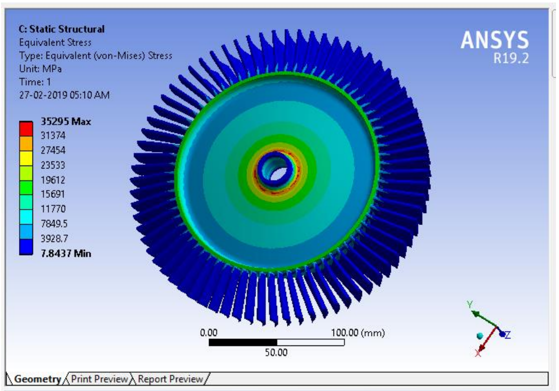

FIG7.5Static Structural

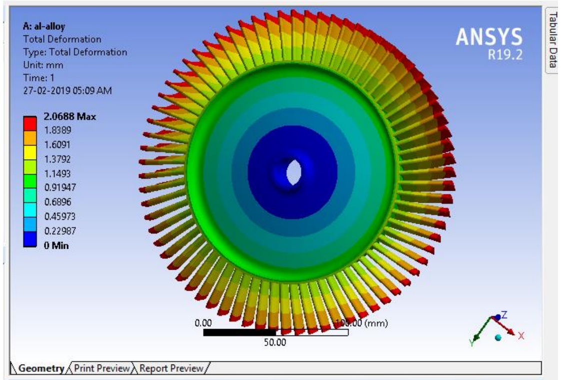

FIG7.6Aluminium Alloy

7. Conclusion

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 elongation and temperatures are observed at the blade tip section and maximum elongation and temperature variations at the root of the blade.

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