A Review of Gas Turbine Rotor Blade Design

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ABSTRACT

The gas turbine obtains its power by utilizing the energy of burnt gases and the air which is at high temperature and pressure by expanding through the several rings of fixed and moving blades. Since the turbine blades are working at high temperature and pressure there are extreme stresses developed on turbine blades. The first centrifugal stresses act on the blade due to high angular speeds, and second is thermal stresses that arise due to temperature gradient within the blade material. The present paper is review of various analyses done on turbine blades and there are various factors effects on turbine blade. This paper will be helpful for those who are working in the area of power plants.

Keywords: Gas Turbine Blade, Finite Element Analysis, Thermal Analysis

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1. Introduction

It is clear that in the 19th Century the concept of the gas turbine became known to many engineers and the efforts of all the pioneers are well documented. In the early part of the 20th Century several trials took place. Early on it was recognized that this was a technological concept with huge potential being limited only by the state of art of associated technologies and the materials available at that time. By the late 1930s the concept of the gas turbine had been around for decades with articles already having being published and patents applied for up to 50 years ahead of the realization of the goal.

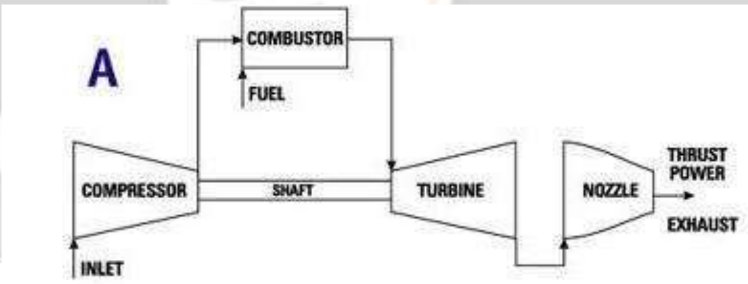

Fig 1. A diagram of an aircraft gas turbine engine

Experimental gas turbines had been around in various forms since the early 1900s and in a following chapter the efforts of the Pioneers are given the credit that they deserve. The question of who came first is also addressed. The early efforts to make the gas turbine work often resulted in disappointment as the poor efficiencies initially achieved meant that there was little incentive to take the idea further [5].

2. Literature Review

In this Chapter focuses on the literature review on gas turbine rotor blade design configuration.

Khawaja and Moatamedi (2014), In this work a gas turbine blade of a small turbofan engine, where geometry and aerodynamic data was available, was analyzed for its structural behavior in the proposed mission envelope, where the engine turbine is subjected to high thermal, inertial and aerodynamic loads. Multiphysics Finite Element (FE) linear stress analysis was carried out on the turbine blade. The results revealed the upper limit of Ultimate Tensile Strength (UTS) for the blade. Based on the limiting factor, high performance alloys were selected from the literature. The two most recommended alloy categories for gas turbine blades are NIMONIC and INCONEL from where total of 21 types of INCONEL alloys and 12 of NIMONIC alloys, available on commercial bases, were analyzed individually to meet the structural requirements. After applying selection criteria, four alloys were finalized from NIMONIC and INCONEL alloys for further analysis. On the basis of stress-strain behavior of finalized alloys, the Multiphysics FE nonlinear stress analysis was then carried out for the selection of the individual alloy by imposing a restriction of Ultimate Factor of Safety (UFOS) of 1.33 and yield strength. Final selection is made keeping in view other factors like manufacturability and workability in due consideration.

Gowreesh et al (2009), studied on the first stage rotor blade of a two-stage gas turbine has been analysed for structural, thermal, modal analysis using ANSYS 11.0. which is a powerful Finite Element Method software. The temperature distribution in the rotor blade has been evaluated using this software. The design features of the turbine segment of the gas turbine have been taken from the preliminary design of a power turbine for maximization of an existing turbo jet engine. it has been felt that a detail study can be carried out on the temperature effects to have a clear understanding of the combined mechanical and thermal stresses.

Kauthalkar et al (2010), the purpose of turbine technology is to extract, maximum quantity of energy from the working fluid to convert it into useful work with maximum efficiency. That means, the Gas turbine having maximum reliability, minimum cost, minimum supervision and minimum starting time. The gas turbine obtains its power by utilizing the energy of burnt gases and the air. This is at high temperature and pressure by expanding through the several rings of fixed and moving
blades. A high pressure of order 4 to 10 bar of working fluid which is essential for expansion, a compressor is required. The quantity of working fluid and speed required are more so generally a centrifugal or axial compressor is required. The turbine drives the compressor so it is coupled to the turbine shaft.

John et al (2012), studied on the design and analysis of Gas turbine blade, CATIA is used for design of solid model and ANSYS software for analysis for F.E.model generated, by applying boundary condition, this paper also includes specific post-processing and life assessment of blade .HOW the program makes effective use of the ANSYS pre-processor to mesh complex turbine blade geometries and apply boundary conditions. Here under we presented how Designing of a turbine blade is done in CATIA with the help of co-ordinate generated on command to demonstrate the pre-processing capabilities, static and dynamic stress analysis results, generation of Campbell and Interference diagrams and life assessment. The principal aim of this paper is to get the natural frequencies and mode shape of the turbine blade.

Deepu et al (2012) Studied on a Gas turbine is a device designed to convert the heat energy of fuel in to useful work such as mechanical shaft power. Turbine Blades are 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 loads. Also, the temperature has significant effect on the blades. Therefore, the coupled (static and thermal) analysis of turbine blades is carried out using finite element analysis software ANSYS. In this paper the first stage rotor blade of the gas turbine is created in CATIA V5 R15 Software. This model has been analysed using ANSYS11.0. The gas forces namely tangential, axial was determined by constructing velocity triangles at inlet and exist of rotor blades. After containing the heat transfer coefficients and gas forces, the rotor blade was then analysed using ANSYS 11.0 for the couple field (static and thermal) stresses.

Jiang and Yang (2010), research of life prediction and damage control for improving the reliability and machinability of a gas turbine. The common modes of failure in gas turbines are creep and fatigue.

Narendranath and Suresh (2012), the first stage rotor blade off the gas turbine has been analyzed using ANSYS 9.0 for the mechanical and radial elongations resulting from the tangential, axial and centrifugal forces. The gas forces namely tangential, axial was determined by constructing velocity triangles at inlet and exist of rotor blades.

Manohar et al (2015), made an attempt to understand the design criteria used for the design of gas turbine disc running at maximum speed of 12000 R.P.M and operating at a temperature of 1300deg centigrade.

Joshi and Jaiswal (2014), presented the design of Axial flow compressor for a given mass flow rate and required pressure ratio by using mean line method. The parameters include thermodynamic properties of the working fluid, number of rotor and stator blades, tip and hub diameters, stage efficiency, blade dimensions (chord, length and space) for both rotor and stator, flow and blade angles (blade twist), Mach number.

George and Titus (2014), described about gas turbine blades will subject to high tangential, axial and centrifugal forces during their working conditions. While withstanding these forces gas turbine blades may subjected to elongation. Summarizes the design, analysis and modification of the cooling passage in the gas turbine blade design.

Htwe et al (2015), Gas turbines have a vital part in electric power generation. Gas turbine innovation is utilized as a part of an assortment of arrangements for electric power age. Turbine rotor cutting edges are the most critical segments in a gas turbine control plant. Turbine cutting edges are mostly influenced because of static burdens. Additionally, the temperature has critical impact on the gas turbine rotor cutting edges. This paper outlines the plan and unfaltering state warm investigation of gas turbine rotor cutting edge, on which Cosmo programming is utilized for stoop of strong model of the turbine sharp edge.

3. CONCLUSION

- The main objective of this paper is to taken an account of previous work carried out on gas turbine blade.
- From the review it can be noted that there are various factors like blade angle, blade geometry, number of perforated holes and the material of the blade can affect structural as well as thermal properties.
- The blade with holes has the best temperature distribution when compared other configurations of the blade for the coolant as per many literatures.
- The blade temperature attained and thermal stresses induced in Copper, Titanium and Nickel as it has better thermal properties, so this was used for next further work.

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