Design and analysis of aero turbine disc by fea: A Review

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***Abstract*: A gas turbine, also called a combustion turbine, is a type of internal combustion engine 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 mounted over a disc. The major function of the turbine is to extract energy from the hot gas flow to drive the compressor and the accessory gearbox. Gas turbine discs work mostly at high temperature gradients and are subjected to high rotational velocity. High speed results in large centrifugal forces in discs and simultaneous high temperature results in thermal stress. The stress which greatly influence the design of turbine disc is the thermal stress. Thus a model of H.P turbine is created using CATIA V5 and the exported to ANSYS 16.0 to perform transient thermal analysis. The thermal analysis performed with three different materials i.e. SUPERALLOY A286, INCONEL 718, and UDIMET 720. The comparison of all material will result in better use of turbine disc material at different stages of combustion.**

***Keywords*: Gas Turbine, Turbine Disc, A286, INCONEL718, UDIMET 720, Thermal analysis, Ansys, Catia.**

I. INTRODUCTION

Rotating discs are historically of interest to designers in the aerospace industry because of their vast range of uses. Gas turbine discs are an important example of such applications. The turbine has the task of providing the power to drive the compressor and accessories and, in the case of engines which do not make use solely of a jet for propulsion, of providing shaft power for a propeller or rotor. It does this by extracting energy from the hot gases released from the combustion system and expanding them to a lower pressure and temperature. A turbine disc has to rotate at high speed in a high temperature environment and is subjected to large rotational and thermal stresses. The service life of critical gas turbine components is governed by the modes of degradation and failure such as: fatigue, fracture, yielding, creep, corrosion, erosion, wear, etc. Gas turbine discs are usually the most critical engine components, which must endure substantial mechanical and thermal loading. If a problem arises in the turbine section it will significantly affect the whole engine function and, of course, safety of the gas turbine engine.

The early materials used were high temperature steel forgings, but these were rapidly replaced by cast nickel base alloys which give better creep and fatigue properties. In the past, turbine discs have been made in ferritic and austenitic steels but nickel based alloys are currently used. Increasing the alloying elements in nickel extend the life limits of a disc by increasing fatigue resistance. Alternatively, expensive powder metallurgy discs, which offer an additional 10% in strength, allow faster rotational speeds to be achieved.

Since the design of turbo machinery is complex, and efficiency is directly related to material performance, material selection is of prime importance.

Fig: High Pressure and Low pressure turbine disc

II. LITERATURE REVIEW

[1] Amr Elhefny, Guozhu Liang

This paper presents a two-dimensional (2D) axisymmetric model for a non-uniform disc was analyzed using FE analysis. The stresses and deformations developed as a result of the disc operating conditions at high rotational speeds and thermal gradients were evaluated using two types of heat transfer modes—conduction and convection, taking into consideration the material behavior at elevated temperatures. The greatest stresses in the disc result from the thermal load caused by conduction, and they are located at the center of the disc. In addition, an analytical method was used to evaluate and predict the stresses along the disc, and it gave a good estimate of the stress values compared to the FE model. Based on this estimate, a parametric study was conducted for a range of rotational velocities under high temperature loads for a series of disc radii. Finally, it was found that this method can be used for the preliminary design of different turbines.

[2] Theju V, Uday P S , Plv Gopinath Reddy

This paper aims to find out the better material by comparing two material. This paper presents a designed turbine blade with two different materials named as Inconel 718 and Titanium T-6. An attempt has been made to investigate the effect of temperature and induced stresses on the turbine blade. A thermal analysis has been carried out to investigate the direction of the temperature flow which is been develops due to the thermal loading. A structural analysis has been carried out to investigate the stresses, shear stress and displacements of the turbine blade which is been develop due to the coupling effect of thermal and centrifugal loads. An attempt is also made to suggest the best material for a turbine blade by comparing the results obtained for two different materials (Inconel 718 and titanium T6). Based on the plots and results Inconel718 can be consider as the best material which is economical, as well as it has good material properties at higher temperature as compare to that of TitaniumT6.

[3] Lakshman Kasina, Raghavan Kotur, Govindaraji Gnanasundaram

The objective of this paper is to design a turbine disk for minimum weight. A numerical investigation is performed to predict stresses and burst margins of turbine disk. A parametric disk model is developed with bore width, bore height, web width and web height parameters. Optimization of turbine disk design is carried out to achieve minimum weight. Sensitivity studies are carried out to understand the geometry parameters influence on the stress and burst margins. The optimization technique was performed to improve the design without compromising on stresses in the disk and burst margin. It was observed that 24% reduction in weight was possible

[4] Shailendra Kumar Bohidar1, Ravi Dewangan

This paper provides a review about the advanced materials used in different components of gas turbine. Design of Turbo machinery is complex and efficiency is directly related to material performance, material selection is of prime importance. Temperature limitations are the most crucial limiting factors to gas turbine efficiencies. The problems at various components are of different magnitudes. As a result, the materials selection for individual components is based on varying criteria in gas turbines. Also materials and alloys for high temperatures application are very costly. This paper is focused on the study of various materials for their applicability for different components of gas turbine for increasing the performance, reliability and emissions in gas turbines. This paper focus light on above issues and each plays an important role within the Gas Turbine Material literature and ultimately influences on planning and development practices. It is expected that this comprehensive contribution will be very beneficial to everyone involved or interested in Gas Turbines.

[5] Dianyin Hu, Rongqiao Wang, Guicang Hou

A new lifetime criterion for withdrawal of turbine components from service is developed in this paper based on finite element (FE) analysis and experimental results. Finite element analysis is used to determine stresses in the turbine component during the imposed cyclic loads and analytically predict a fatigue life. Based on the finite element analysis, the critical section is then subjected to a creep-fatigue test, using three groups of full scale turbine components, attached to an actual turbine disc conducted at 750 C. The experimental data and life prediction results were in good agreement.

[6] R.A. Cláudio, C.M. Branco, E.C. Gomes, J. Byrne

In this paper, an FE detailed study of a gas turbine test disc, subjected to similar conditions as in the rim-spinning test, is presented. Finite element analysis were derived from a plain disc (without cracks) and for a geometry with two types of cracks, both at the notch root of the blade insert and located in the corner and in the center (central crack). Using a crack propagation program with appropriate fatigue creep crack growth rate data, previously obtained in specimens for the nickel base super alloy IN718 at 600ºC, fatigue life predictions were made. The predicted life results were checked against experimental data obtained in real test discs, and very good agreement was found.

III. CONCLUSION

From the above literature survey I find that many studies and research has been carried out on gas turbine disc.
It has been found out that the major challenge facing turbine design is reducing the effect of creep and fatigue that is induced by the high temperature environment, tremendous centrifugal and aerodynamic forces caused by blades and it limits the service life.
Thus, I have decided to perform a finite element analysis on aero gas turbine disc operating under high temperature environment using ANSYS 16.0 using three most prominent materials and comparing the behavior or material under high thermal stress and then suggesting the better use of turbine disc material on different stages of combustion process.

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