The Design and Analysis of Gas Turbine Blade

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Abstract— ***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 expending 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. After compression the working fluid are to be expanded in a turbine.***

Keywords— ***Gas Turbine, Maximum efficiency, combustion chamber, compressor, stating time.***

I. INTRODUCTION

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, to get a high pressure of order of 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 centrifugal or axial compressor is required. The turbine drive the compressor so it is coupled to the turbine shaft. If after compression the working fluid were to be expanded in a turbine, then assuming that there were no losses in either component, the power developed by the turbine can be increased by increasing the volume of working fluid at constant pressure or alternatively increasing the pressure at constant volume. Either of there may be done by adding heat so that the temperature of the working fluid is increased after compression. To get a higher temperature of the working fluid a combustion chamber is required where combustion of air and fuel takes place giving temperature rise to the working fluid. The turbine escapes energy from the exhaust gas. Like the compressor, turbine can be centrifugal or axial. In each type the fast moving exhaust gas is used to spin the turbine, since the turbine is attached to the same shaft as the compressor at the front of the engine, and the compressor will turn together, The turbine may extract just enough energy to turn the compressor. The rest of the exhaust gas is left to exit the rear of the engine to provide thrust as in a pure jet engine. Or extra turbine stages may be used to turn other shafts to power other machinery such as the rotor of a helicopter, the propellers of a ship or electrical generators in power stations. The present paper deals with the first type is centrifugal stresses that 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 analysis of turbine blade mainly consists of the following two parts: Structural and thermal analysis. The analysis is carried out under steady state conditions using Ansys software.

II. DESIGN PROCEDURE

A turbo machine blade is usually a cantilever beam or plate is tapered and twisted with an airfoil cross section. Typically a turbo machine has several stages, each stage with a stator and rotor. In the stator, they are all inserted as diaphragms or nozzles in a ring to guide the flow medium at an appropriate entry angle into rotor blades. The rotor blades are mounted on a disc at a stagger angle to the machine axis and they convert the thermal energy into mechanical energy in turbine. In turbine steam enters at high pressure and temperature in the first stage and expands while passing through the several stages before it is let out from the last Stage with low temperature and pressure after extracting as much as thermal energy as possible. Hence, the short blades in high pressure have high frequency of the order of 1000Hz, which becomes progressively lower about 100Hz in the last stage long blades. In the compressor stage, the operation principle is reversed to compress the gases utilizing the supplied mechanical power. A typical rotor blades sees upstream disturbances from the stator row and as it rotates, receives a corresponding number of increasing and decreasing lift and moment alternating periodically depending on the number of stator blades/nozzles/guide vanes. A stator blade can also be imagined to rotate in an opposite direction to the rotor relative to the moving row and thus receives a corresponding number of periodic forces and moments equal to the rotor blades. An ideal placement of blades in the stator is not feasible in practice. Firstly, the blades are not all identical in their cross section along the length, their pitch distance from blade to blade varies, and the axial and angular locations will have some errors in mounting them in the stator housing.

Because of these errors in the stator, mechanical excitation at rotational speed and its harmonics occurs on the rotor blades.

III. EXPERIMENTS SETUP

In this chapter the experiments performed to obtain structural and thermal analysis of the turbine blade are discussed. This discussion is divided into two parts. First the experimental setup is discussed on thermal analysis using different mayterials. Second the experimental setup on structural analysis using different materials are discussed and finally the obtain material is compared with the existing material is evaluated.

3.1.Thermal analysis:showing temperature distribution using different materials

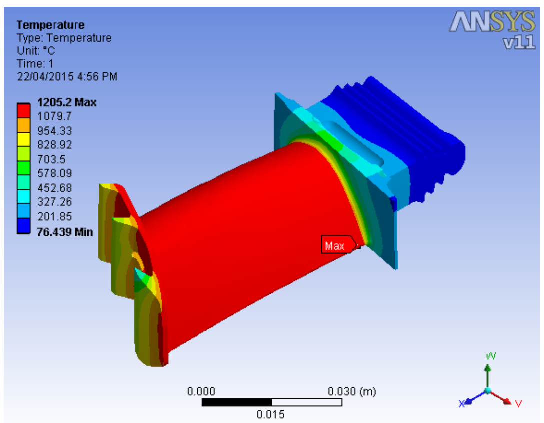


FIG.3.1..Titanium Alloy

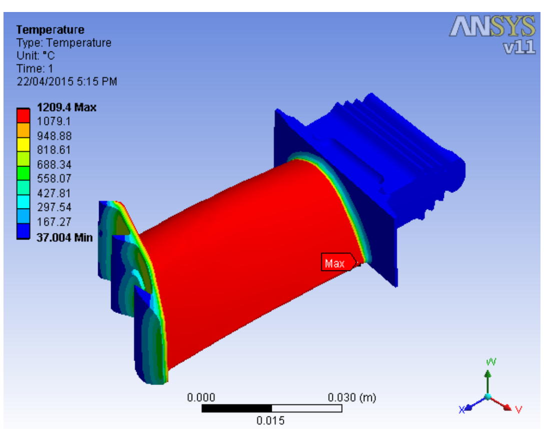


FIG.3.2..Lanthanum zirconiumoxide

3.2.Structural analysis: equivalent stresses on blade using different materials

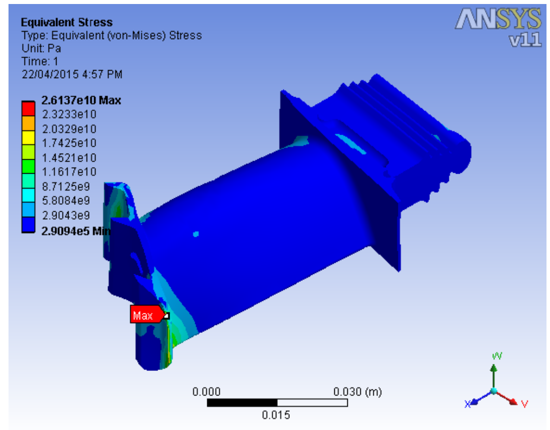


FIG.4.7.Titanium Alloy

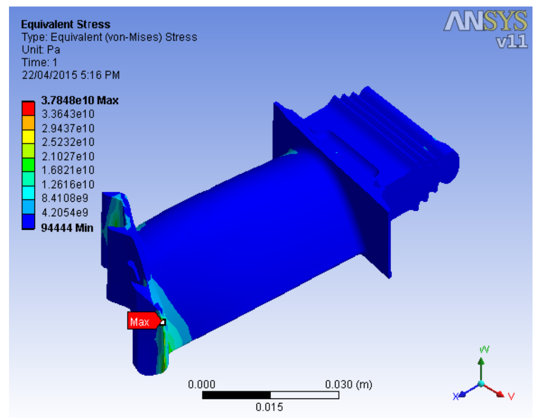


FIG.4.8.Lanthanum zirconiumoxide

IV. RESULT

5.1.stress-radius graph

For titanium alloy

radius(m) : Stress 6 (r)

0.034 : 26.13

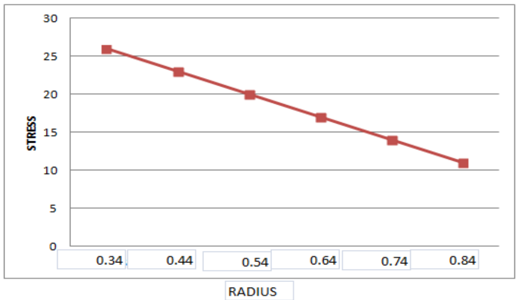
0.044 : 23.23

0.054 : 20.39

0.064 : 17.42

0.074 : 14.52

0.084 : 11.61



5.3.For Lanthanum zirconiumoxide

radius(m) : Stress 6 (r)

0.034 : 37.84

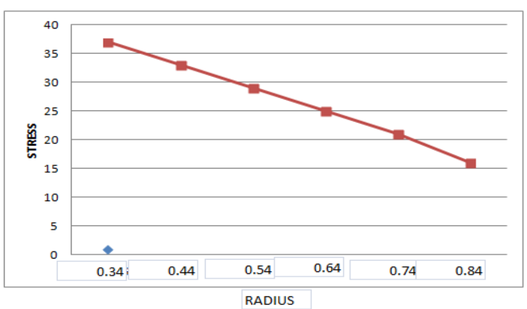
0.044 : 33.63

0.054 : 29.43

0.064 : 25.23

0.074 : 21.02

0.084 : 16.82



From above four graphs, i.e. stress – radius graph, it is conclude that the stress is minimum by using this new material i.e. LANTHANUM ZIRCONIUMOXIDE.

V. CONCLUSION

In this study, that the structural analysis and the thermal analysis for different turbine blade material is examine. Different turbine blade material is tested as compared with the existing turbine blade material. It was observed that **La2Zr2O7** (Lanthanum zirconiumoxide) material is safe as compared to the other materials. Also, the result was validated by comparison with the analytical values and the software values. Hence, the **La2Zr2O7** (Lanthanum zirconiumoxide) material is best for the present application.

Through this analysis, the followings are summarized and pointed out

- On the basis of total deformation, equivalent stress, strain energy lost, total energy loss temperature distribution,total heat flux and thermal error the La2Zr2O7 (Lanthanum zirconiumoxide) material is safe.
- On the basis of shear stress Titanium Alloy is more safe.
- On the basis of Mass of single blade, AlSi (Aluminium Silicate) is safe.
- But, the overall pressure analysis and thermal analysis the La2Zr2O7 (Lanthanum zirconiumoxide) material is much better than the other materials.

VI. FUTURE SCOPE

- CAD model of gas turbine blade.
- Design and analysis with the help of software.
- Identification of problems occurring in gas turbine blade.
- Structural and thermal analysis of blade by using FEM.
- Reduces the failures in the blade of turbine which may helps to improve its efficiency.

This work may go for CFD analysis for actual flow velocity of fluid.Also it can obtain shape optimization analysis.

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