Finite Element Stress Analysis of Gas Turbine Blade

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***Abstract*— Gas turbines have an important role in power generation and propulsion unit. Turbine blades are the most important components in a gas turbine power plant. Turbine blades are mainly affected due to static loads. Gas turbine blades will subject to high tangential, axial and centrifugal forces during their working conditions. The stress distribution due to the flow of gases and the impact of flow gases are considered. The gas turbine rotor blade was performed to determine the regions of maximum stress and moment which occur on a typical gas turbine engine at variable rotational speeds. The results document the effect of velocities, pressure, temperatures and Mach numbers etc. In this paper the second stage of axial-flow gas turbine rotor blade with holes is created in SolidWorks software and design calculation is computed by MATLAB software. The finite element stress analysis on second stage rotor blade with holes is analysed from ANSYS 14.5 software. Three different models with different number of holes (5, 9 and 13) were analyzed to find out the optimum number of holes for good performance.**

***Keywords*— Rotor blade, Ansys 14.5, Solid Works, Gas Turbine**

I. INTRODUCTION

Gas turbine technology is used in a variety of configurations for electric power generation. 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. A gas turbine is a device designed to convert the heat energy of fuel into useful work such as mechanical shaft power.

In a gas turbine power plant, a turbine, which is used as a prime mover, converts the kinetic energy of the gases into mechanical energy and drive electric generator that generates the electrical power. The operation of a gas turbine depends upon the characteristics of its major components such as the compressor, combustor and turbine. The fundamental idea with a turbine is to extract work from the incoming airflow and convert it into mechanical work at a rotating axis.

The gas turbine power plants can be classified into two categories. These are open cycle gas turbine power plant and closed cycle gas turbine power plant. The simple open cycle gas turbine is suitable for industrial gas turbine. The turbine is a rotary mechanical device that extracts energy from a fluid flow and converts into useful work. The gas turbine obtains its power by utilizing the energy of burnt gases and the air which is at high temperature and pressure.

II. MATERIAL AND METHODS

In this work, the finite element stress analysis of the gas turbine rotor blade is made of structural steel was carried out.

Table 1 shows the properties of structural steel.

TABLE I
Material Properties of Structural Steel

Material Properties	Magnitudes
Density	7850kg/m^3
Modulus of elasticity	110GPa
Poisson's ratio	0.30
Thermal expansion coefficient	2.2e-5/k
Maximum Allowable Temperature	2300 °K
Thermal conductivity	9.6W/m °K

The holes on the blade tip are arranged on the mid camber line of the blade tip section. Turbine second stage axial blade chord length is 64.5mm and cooling passage diameter is 1.4mm. It is shown in Figure 1, the blade consisting of 5 holes, in Figure 2, the blade consisting of 9 holes and in Figure 3, the blade consisting of 13 holes.

Fig1. Turbine second stage rotor blade with 5 holes

Fig2. Turbine second stage rotor blade with 9 holes

Fig3. Turbine second stage rotor blade with 13 holes

III. ANALYSIS

Turbine second stage rotor blades have three different holes configuration. As shown in Fig.4, the first step was to construct the turbine blade using the SolidWorks software. The second step was to select the material for the geometry and then give boundary setting. In preprocessing modeling and mesh is generated by using ANSYS 14.5. Meshing of model is done in ANSYS workbench. A complete workflow of the meshing is presented in Fig.5. Turbine rotor blade is analyzed under a fixed position and revolution of 5100 rpm. The applied forces on the rotor blade are centrifugal force, tangential force and axial force. After boundaries conditions are setting and then solve the problems for simulation results are obtained.

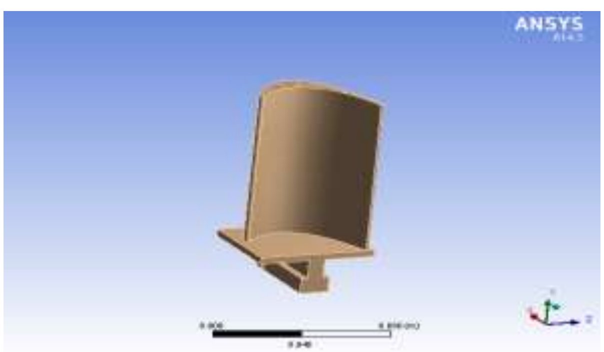

Fig4. Solid Model of Turbine Second Stage Rotor Blade with Five Holes

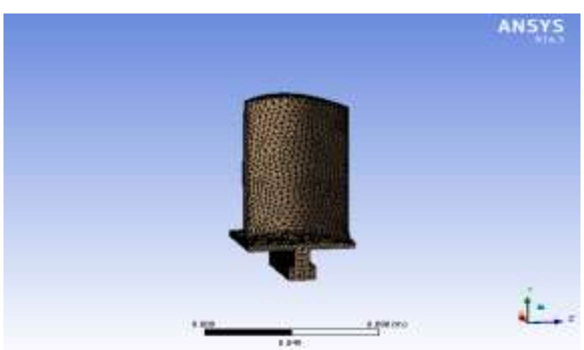

Fig5. Meshing of Turbine Second Stage Rotor Blade with Five Holes

These are analyzed under the fixed position and revolution of 5100rpm. Equivalent forces on blades are calculated and applied in ANSYS 14.5. The von-Mises stress for turbine second stage rotor blade (with five holes) is illustrated in Fig. 6. The Equivalent von-Mises stress on the rotor blade is 125.0010MPa while the yield strength of the blade material is 250MPa. The rotor blade (with five holes) will work safety at this stress.

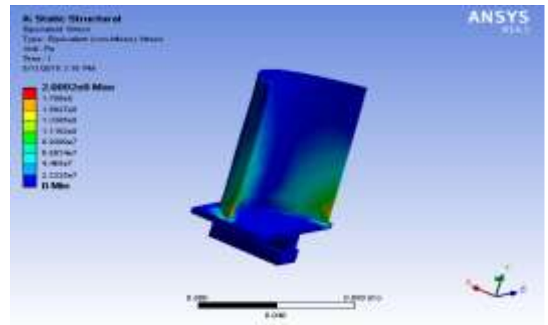

Fig6. Equivalent (von-Mises) Stress in Turbine Second Stage Rotor Blade (with five holes)

The von-Mises stress for turbine second stage rotor blade (with nine holes) is illustrated in Fig.7. The Equivalent von-Mises stress on the rotor blade is 130.0010MPa while the yield strength of the blade material is 250MPa. The rotor blade (with nine holes) will work safety at this stress.

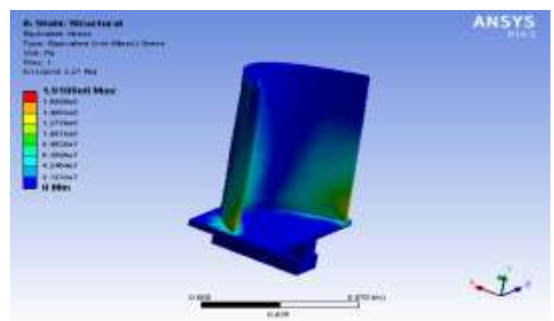

Fig7. Equivalent (von-Mises) Stress in Turbine Second Stage Rotor Blade (with nine holes)

The von-Mises stress for turbine second stage rotor blade (with thirteen holes) is illustrated in Fig.8.

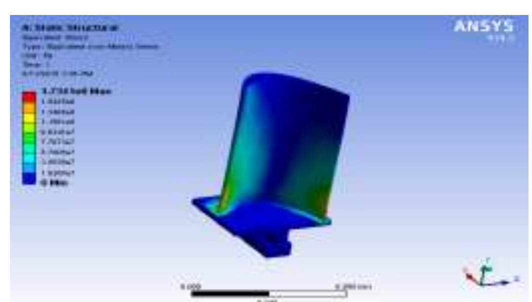

Fig8. Equivalent (von-Mises) Stress in Turbine Second Stage Rotor Blade (with thirteen holes)

The Equivalent von-Mises stress on the rotor blade is 136.0010MPa while the yield strength of the blade material is 250MPa. The rotor blade (with thirteen holes) will work safety at this stress.

IV. RESULTS AND DISCUSSION

The finite element thermal analysis of gas turbine rotor blade is carried out using ANSYS 14.5 software. The temperature has a significant effect on the overall turbine blades. The finite element stress is analyzed for three different the number of holes. The analysis results of the three different the number of holes are not exceeded the yield stress of material. The maximum von-Mises stresses of turbine second stage rotor blade (with 5, 9, and 13 holes) are 125MPa, 130MPa and 136MPa. The turbine second stage rotor blade of maximum von-Mises stress is observed at the rotor blade with 13 blade holes. According to the finite element stress analysis, the turbine second stage rotor blade (with 5 holes) design is optimum.

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