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STRUCTURAL ANALYSIS OF GAS TURBINE BLADE BY USING FEA

Geetha S M
E-mail id: geethasm68@gmail.com
Department of Aeronautical Engineering
Acharya Institute of Technology, Karnataka, Bangalore (India)

Abstract-The main objective of this paper is to bring out a material used in the manufacture of the turbines which is less in cost, gives a long run and can withstand all the properties required in required condition. Here, we took three samples of materials that are used in the manufacturing of turbines, and performed Structural analysis on the material in simulation software. All the modelling process is carried out in CATIA v5 and simulation is done in ANSYS Mechanical Workbench.

Key words: Turbines, Structural analysis, simulation, CATIA v5, 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. A working fluid contains potential energy (pressure head) and kinetic energy (velocity head). The fluid may be compressible or incompressible. Several physical principles are employed by turbines to collect this energy.

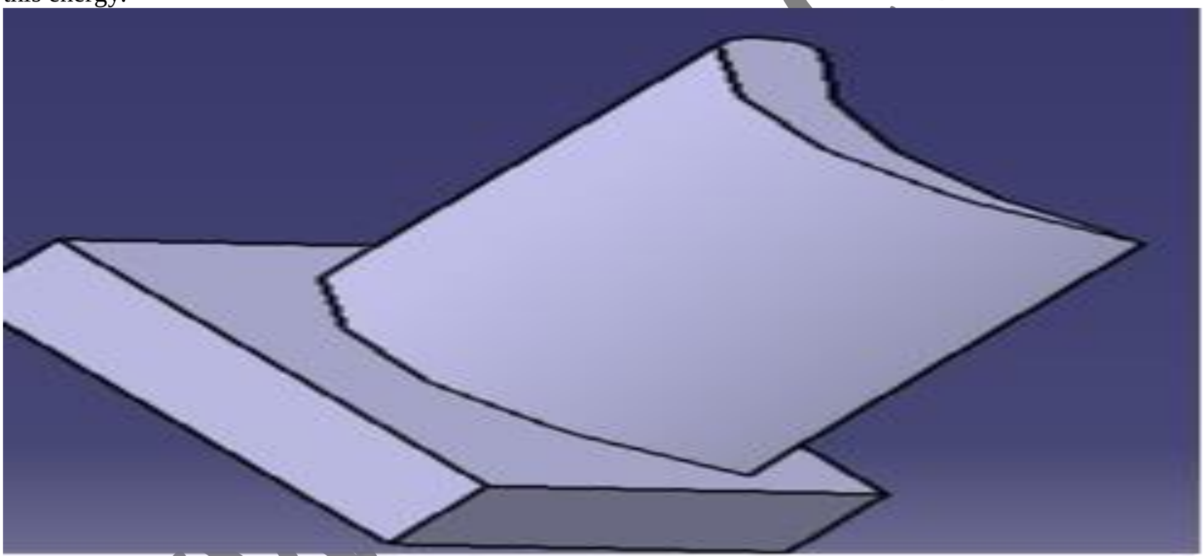

Fig. 1.1 Turbine Blade

2. TURBINE BLADE

A turbine blade is an individual component which makes up the turbine section of a gas turbine. The blades are responsible for extracting energy from the high temperature, high pressure gas produced by the combustor. The turbine blades are often the limiting component of gas turbines. To survive in this difficult environment, turbine blades often use exotic materials like super alloys and many different methods of cooling, such as internal air channels, boundary layer cooling, and thermal barrier coatings. So for this application the gas turbine blade must be casted with a material which has high chemical and physical properties. One of such type of materials is super alloy. Super alloy is that material which exhibits several key characteristics excellent mechanical strength, resistance to thermal creep deformation, good surface stability, and resistance to corrosion or oxidation.

3. LITERATURE SURVEY

Extensive work has been reported in the literature on cooling of gas turbine blade. Deepanraj et.al. [1] Have Considered titanium – aluminium alloy as the blade material and performed structural and thermal analysis with varying number of cooling passages. They also studied the effect of varying the cooling air temperature on the temperature distribution in the blades. It is concluded that the blade configuration with 8 holes gives an optimum blade temperature of 8000C.Bhatti et al. [2] performed transient state stress analysis on an axial flow gas turbine blade and disk using finite element techniques. They have chosen Inconel 718, a high heat resistant alloy of chromium, nickel & niobium. The study was focused on centrifugal & thermal stress arising in the disk. A.K.Mattaet.al. [3] studied the stress analysis for N –155 & Inconel 718 material. On solid blades it is reported that Inconel 718 is better suited for high temperature operation.

4. MODELLING AND ANALYSIS OF GAS TURBINE BLADE

The blade model profile is generated by using CATIA software. The contour (2D model) is then converted into area and then volume (3D model) was generated by extrusion. The hub is also generated similarly. These two volumes are then combined into single volume.

ANSYS procedure:

- Pre-Processor
- Solution
- Post-processor

This model of turbine blade is then imported into ANSYS software. The blade is then analysed sequentially with structural analysis preceding of different materials to find out stress, strain and deformation of material.

5. SELECTION OF MATERIALS

- Nimonic 80A
- Super Alloy grade X
- Titanium Aluminium

Table-5.1 Materials Properties

MATERIALS	NIMONIC 80A	SUPER ALLOY GRADE X	TITANIUM ALUMINIUM
Young's Modulus (GPa)	222	160	110
Density (Kg/m3)	8190	9000	4810
Poisson's Ratio	0.35	0.3	0.3
Thermal Conductivity (w/mk)	24.5	22	8.4
Thermal Expansion	16.2e6	10e6	9.4e6

6. ANALYSIS

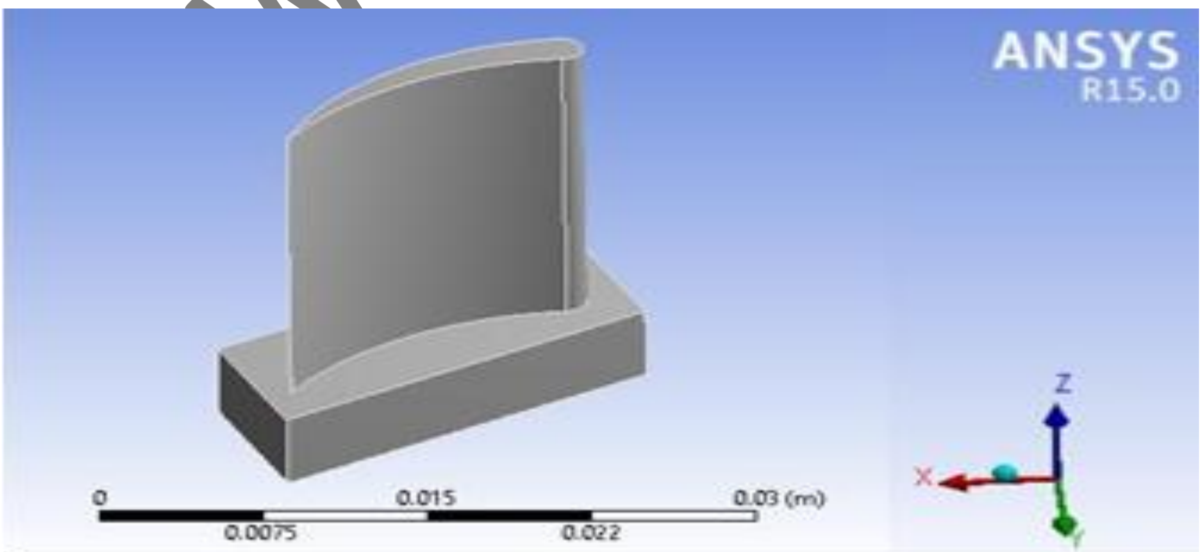

Fig. 6.1 Imported from Catia v5

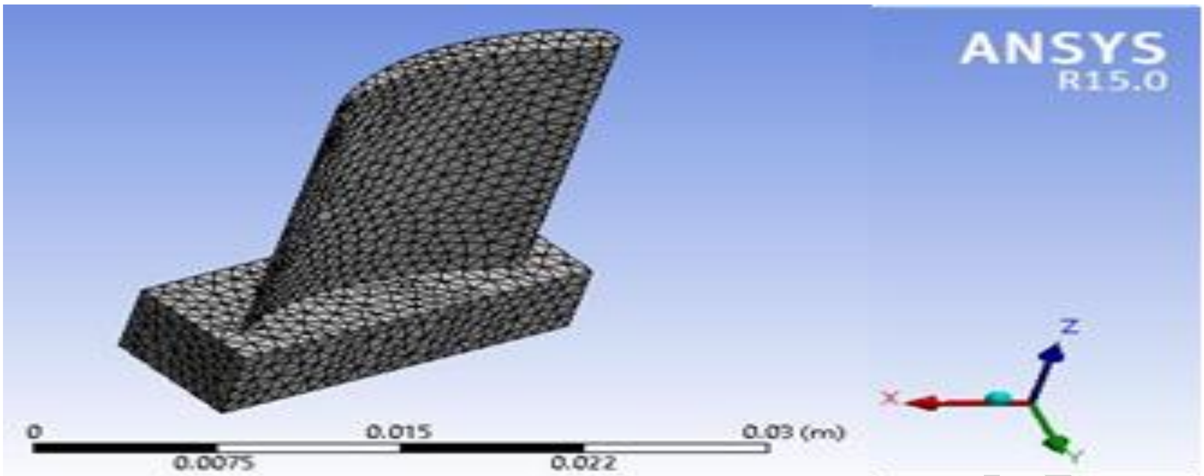

Fig. 6.2 Meshing of the Turbine Blade

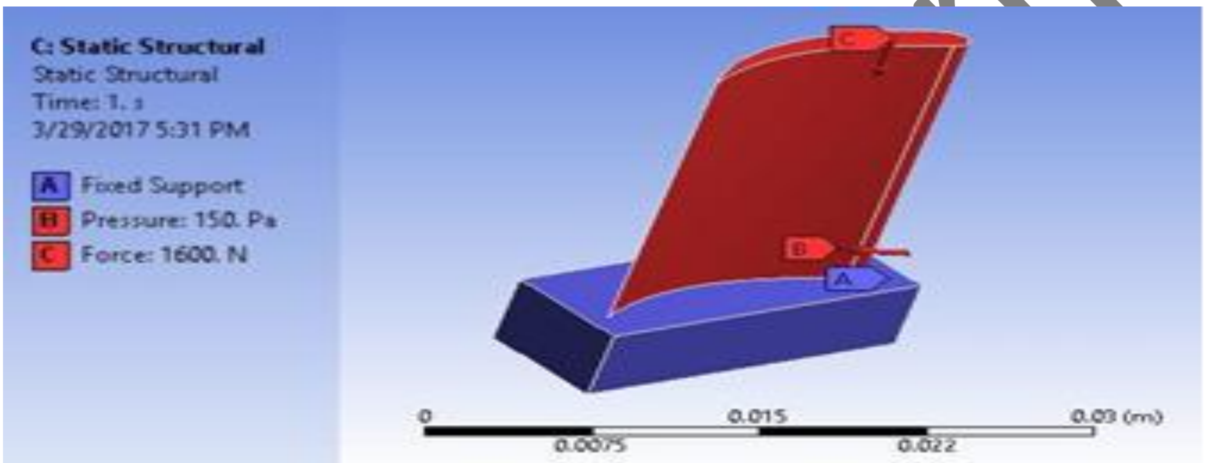

Fig. 6.3 Applying Boundary Conditions

7. RESULT

Table-7.1 Properties of Materials

MATERIALS	TOTAL DEFORMATION	STRESS (N/mm2)	STRAIN
NIMONIC 80A	6788.5	10.307E7	4.7E5
SUPER ALLOY GRADE X	9446.8	9.877E7	6.25E5
TITANIUM ALUMINIUM	13741	9.877E7	9.09E5

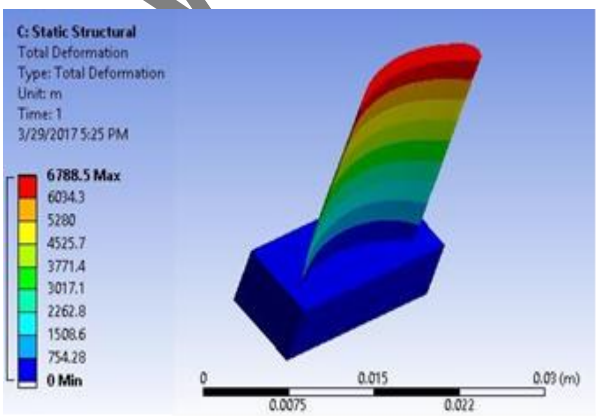

Fig. 7.1Total Deformation in Turbine Blade

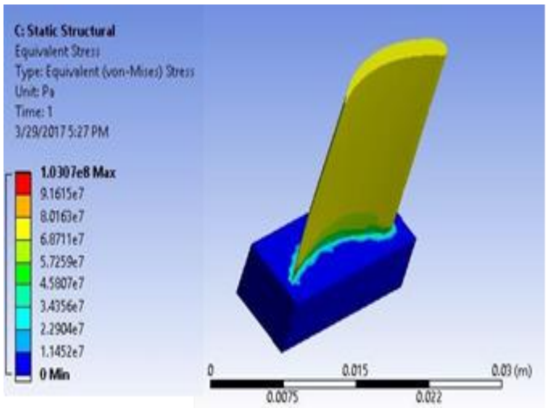

Fig. 7.2 Von-mises Stress in Turbine Blade

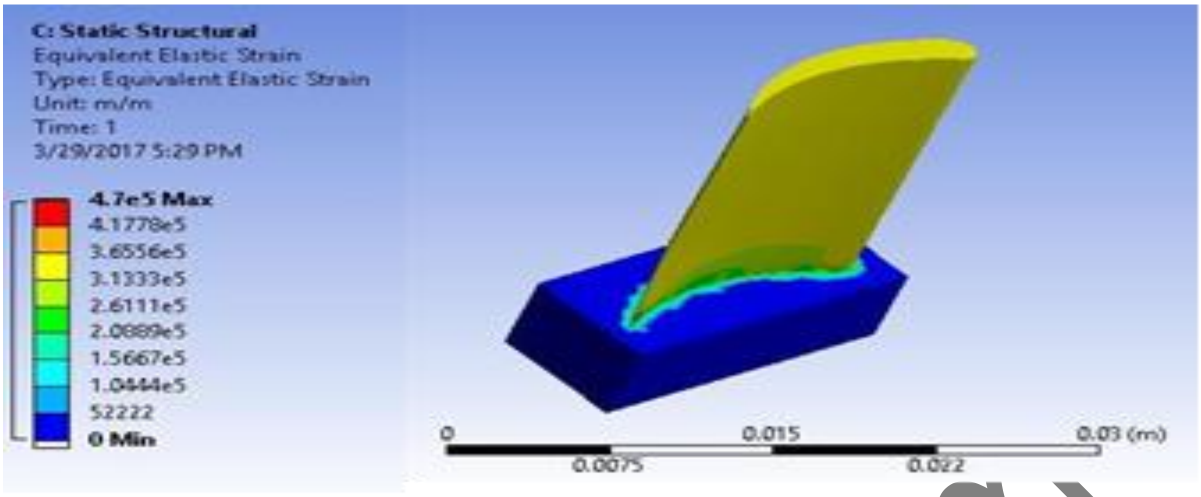

Fig. 7.3Von-mises Strain in Turbine Blade

CONCLUSION

The von misses stresses are obtained as shown on above figure; it is observed that the maximum von misses stress is 10.30e7N/mm2 for Titanium-Aluminium, 9.877e7N/mm2 for SUPER ALLOY GRADE X, 9.877e7N/mm2 for Nimonic 80A alloy. The deformations are obtained as shown in figure; it is observed that the maximum deformation is 13741mm2, 9446.8mm2,6788.5mm2 for Titanium-Aluminium alloy, super alloy grade X and Nimonic 80A alloy respectively. From above discussion it is observed that the stress, deformation are low Nimonic 80A alloy. Nimonic 80 A is having less stresses than other two. Hence we conclude that Nimonic 80A alloy is best suited for turbine blade applications.

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