Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

DESIGN AND ANALYSIS OF TURBO JET ENGINE

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ABSTRACT

It is quite common that every component so designed will be affecting from various deformations and irregularities which may lead to generation of various stresses. So, it is very much essential to analyze the component for various stresses that are to be developed. Here, the analysis of various stresses in a turbojet engine is being done. The main objective is to find out the Displacement, Equivalent and Fatigue stresses of the jet engine blades when subjected to structural and thermal Loads. Structural analysis of a jet engine can be analyzed using finite element analysis techniques. From these techniques the FEA is done in order to find out the stresses in the existing blades for the calculated loads and boundary conditions using Finite Element Analysis Software ANSYS Workbench. This entire work is done in various steps like firstly modelling the turbine in SOLIDWORKS software and importing the geometry into the ANSYS software for the analysis process. The conclusions thus extracted from these analyses are the numerical values of stress concentrations, displacement, thermal stress, various modes of failure for different natural frequencies, and its life in cycles and safety factor. And it is found out that maximum stress is 2207.7MPA.

Key words: Turbo jet engine, Shock absorber, Static Analysis, Thermal Analysis, Fatigue Analysis

I. INTRODUCTION:

The basic operation of the gas turbine is similar to that of the steam power plant except that air is used instead of water. Fresh atmospheric air flows through a fan and compressor that brings it to higher pressure. Energy is then added by spraying fuel into the air and igniting it so the combustion generates a high-temperature flow. This high-temperature high-pressure gas enters a turbine, where it expands in the turbine and produces a shaft work output in the process. The turbine shaft work is used to drive the compressor and other devices such as an electrical generator that may be coupled to the shaft. The remaining energy that is not used for shaft work comes out in the exhaust gas, so these have either a high temperature or a high velocity. The purpose of the gas turbine determines the design so that the most desirable energy form is maximized. Gas turbines are used to power aircraft trains, ships, electrical generators, and tanks.

II .LITERATURE SURVEY:

The idea of utilizing the principle of reaction in aircraft was started since early 17th century and has been dominated by reciprocating engine. Not until the Second World War, the jet-engine technology has been developed to replace the unsuitability of the piston engine to produce high velocity of airflow necessary to carry a propulsive task. In 1913, Rene Lorin patterned the first jet engine. However, it is impossible to manufacture because the suitable heat resisting material was not yet available.

During the WWII, Sir Frank Whittle (Smith, 1995) made a major breakthrough in the jet propulsive technology. He patterns a gas-turbine engine that produces propulsive power, which is called the Whittle engine. The engine has formed the basis of gas-turbine engine, and the technology still widely used ten decades later.

Small scale turbine jet engine is a smaller size turbine jet engine which exhibits similar operating principles as commercial or industrial gas turbine. Nevertheless, they differ in utilization and purpose of its production. While jet engines were constructed mainly for air transportation, the small-scale turbine jet engines are developed for a wider purpose, ranging for research activity (Benini, 2007) to hobbyist

III. MODELLING AND ANALYSIS TURBO JET ENGINE:

Turbo jet engine is designed in Solid works with the following drawing as shown figure.1

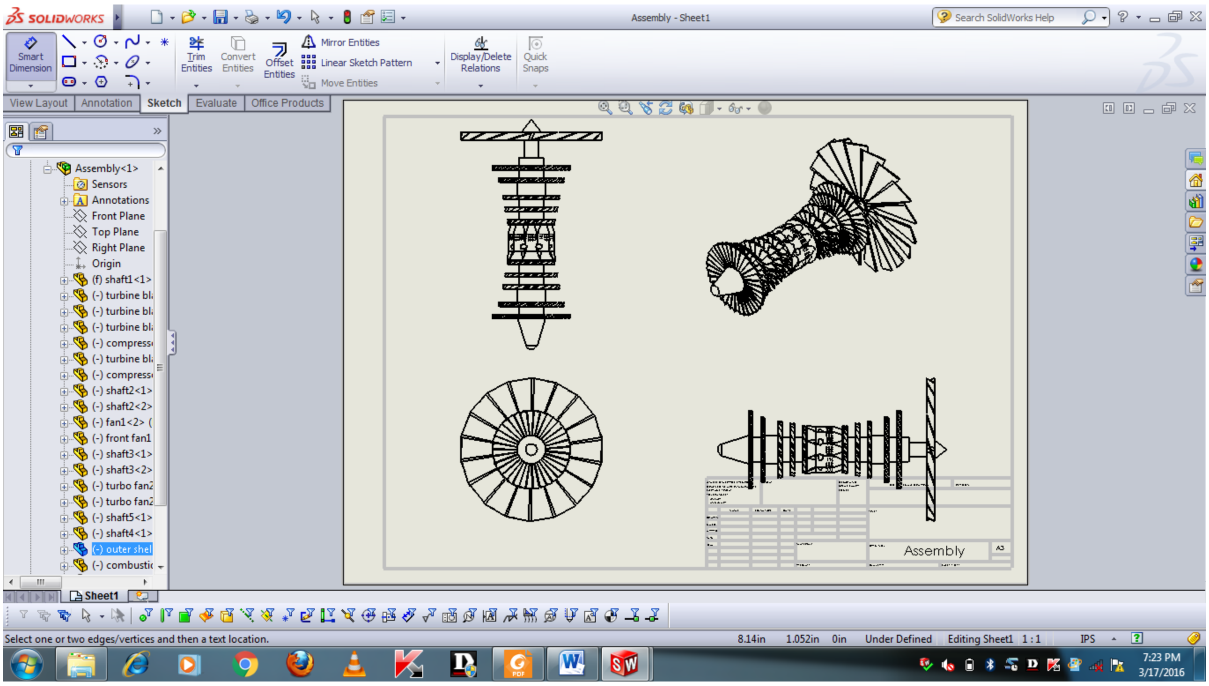


Fig.1 drawing of turbo jet engine

Turbo jet engine modelled in Solid works is shown in Figure2. Then the model is converted in to the IGES format which is most suitable and easy access for any other software. Using the IGES format the turbo jet engine model from Solid works is imported to ANSYS. The turbo jet engine after is meshing is shown in Figure3.Boundary conditions and Loading conditions are shown in Figure 4 and 5 respectively.

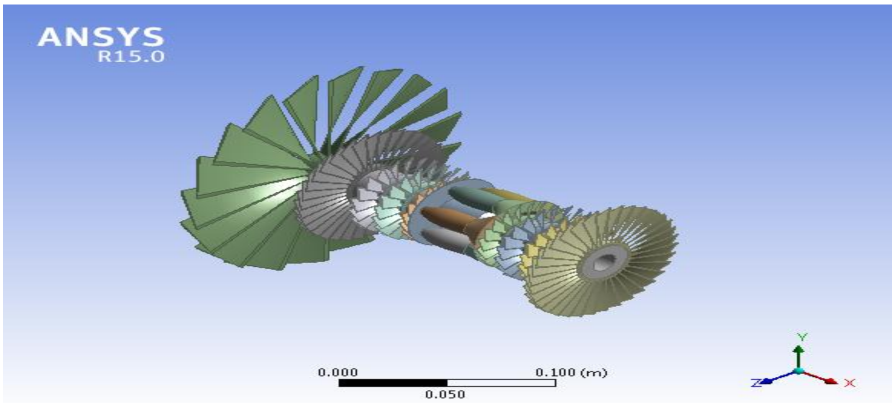


Figure 2: Turbo jet engine modelled in Solid works

MATERIALS PROPERTIES

MATERIAL/PROPERTY	TITANIUM 6AL-4V	HASTE ALLOYX	STAINLESS STEEL	INCONEL718
Density	4430	8220	7850	8190
Youngs modulus	1.15e11	2e11	2e11	2.9e11
Poission ratio	0.342	0.328	0.3	0.294
Yield tensile stress (mpa)	880	245	250	2351
Ultimate tensile stress (mpa)	950	615	460	3241
Compresive yield stress	970	250	250	2509
Thermal conductivity	6.7	28.70	44.99	6.5

Table.1 Material properties

MESHING:

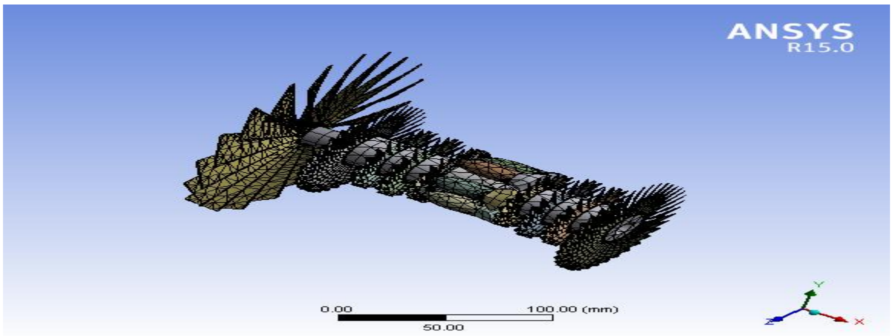


Figure 3: Meshing

BOUNDARY CONDITIONS:

- The Rotational velocity is applied to all bodies is 500 rad/sec.
- The combustor or combustion chamber is applied to fixed support.
- At the inlet of the fan a force of 230N is applied to all the blades.
- A force of 380N is applied to the compressor blades.
- A force of 430N is applied to the turbine blades.
- The backside face of the each blade is applied to fixed support.
- Then click on solution information.

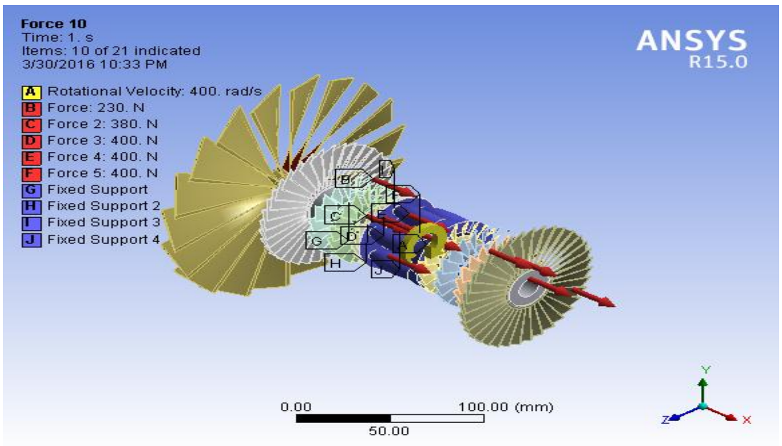


Figure 4: Static Boundary conditions of turbo jet engine

ISSN (Print) : 2320-5504
ISSN (Online) : 2347-4793

SOLUTION INFORMATION:

- Click on solution information and insert the total deformation, equivalent von – mises stress, strain and fatigue tool.
- In the fatigue tool insert damage, life and Factor of safety.
- Click on solve button to obtain solution

STEADY STATE THERMAL ANALYSIS:

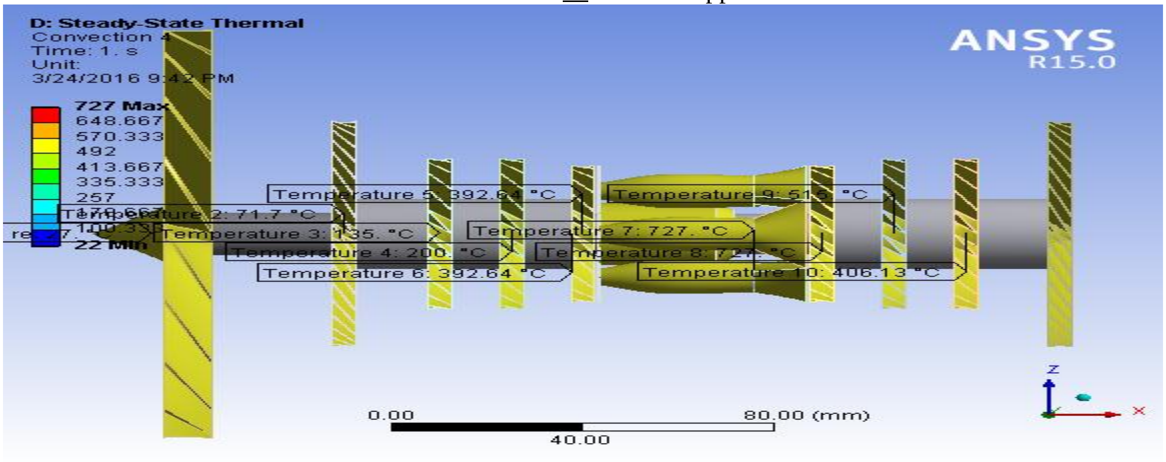
- At each blade the temperature is given as shown below.
- At the fan blades a convective heat transfer of 122W/ °c m^2 is applied.
- At compressor blades a convective heat transfer of 153.7W/ °c m^2 is applied.
- At turbine blades a convective heat transfer of 153.7W/ °c m^2 is applied.
- 

Fig.5 Thermal boundary conditions of turbo jet engine

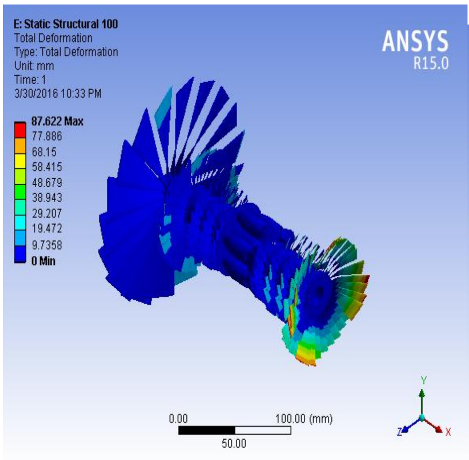
IV. RESULTS AND DISCUSSION:

STATIC STRUCTURAL ANALYSIS:

After the model was imported and meshed, the analysis was done by applying the boundary conditions we get the maximum and minimum values of the total deformation, equivalent von – mises stress and strain as follows.

Name of the property	Maximum value	Minimum value
Total deformation	87.622	0 mm
equivalent(von–mises) stress	2206.7MPA	2.3743e-7
equivalent(von–mises) strain	0.070784	7.8784e-12

Table.2. maximum and minimum values



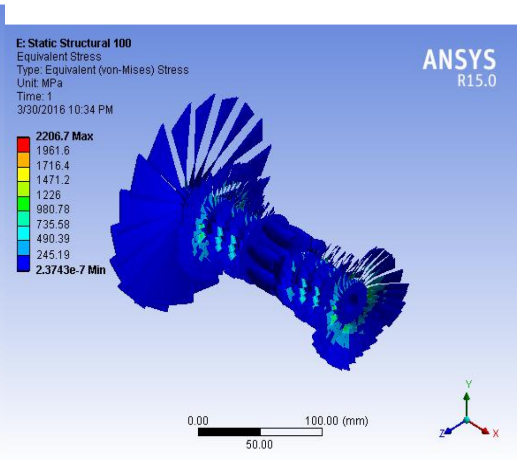


Fig.6 Total deformation Fig.7 Equivalent stress

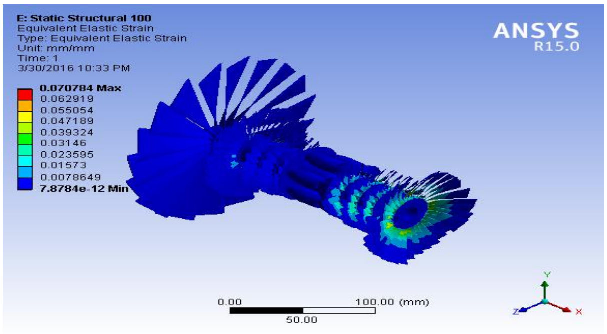
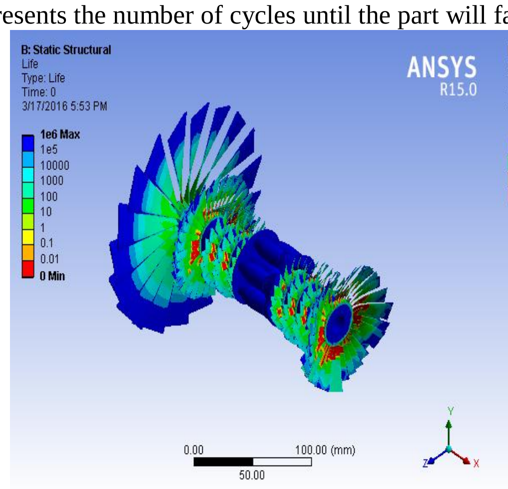


Fig.8 Equivalent strain

FATIGUE ANALYSIS:

LIFE OF JET ENGINE:

This result contour plot shows the available life for the given fatigue analysis. If loading is of constant amplitude, this represents the number of cycles until the part will fail due to fatigue.



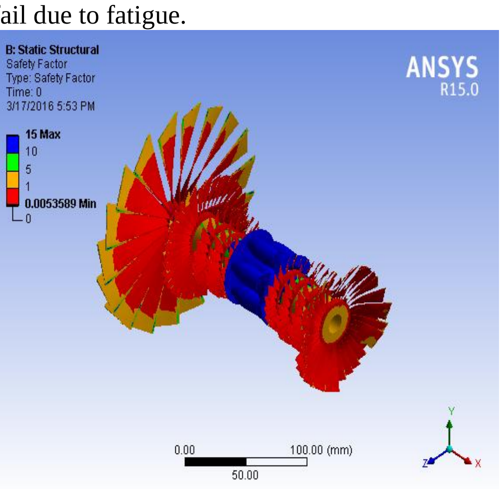


Fig.8 Life of jet engine Fig.9 FOS of jet engine

SAFETY FACTOR:

Factor of safety (FoS), also known as (and used interchangeably with) safety factor (SF), is a term describing the capacity of a system beyond the expected loads or actual loads. Essentially, the factor of safety is how much stronger the system is than it usually needs to be for an intended load. Safety factors are often calculated using detailed analysis because comprehensive testing is impractical on many projects, such as bridges and buildings, but the structure's ability to carry load must be determined to a reasonable accuracy.

$$\text{Factor of Safety} = \frac{\text{Material Strength}}{\text{Design Load}}$$

This result is a contour plot of the factor of safety (FS) with respect to a fatigue failure at a given design life. The maximum FS reported is 15.

DAMAGE:

Fatigue damage is defined as the design life divided by the available life

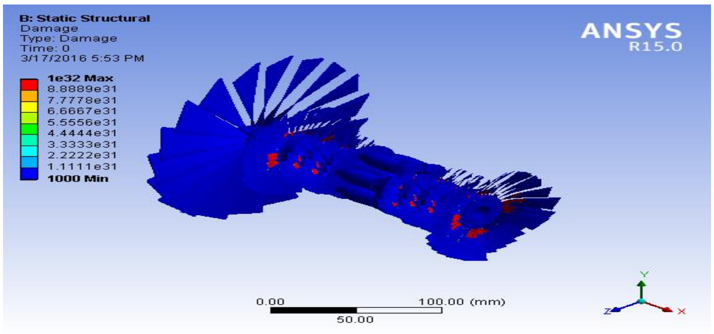


Fig.10 Damage of jet engine

Name of the property	Maximum value	Minimum value
Life	1e6	0
Factor Of Safety	15	0.0053589
Damage	1e32	1000

Table.3

STEADY STATE THERMAL ANALYSIS

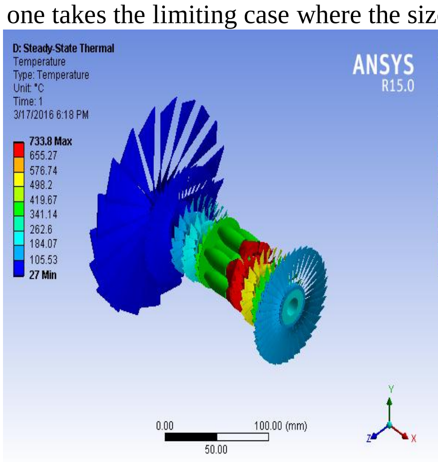
After the model was imported and meshed, the analysis was done by applying the boundary conditions we get the maximum and minimum values of the temperature and total heat flux are obtained.

Name of the property	Maximum value	Minimum value
Temperature	733.8	27
Total Heat flux	$0.33963 W/m^2$	1.6211e-17

Table.4

TOTAL HEAT FLUX:

Heat flux or thermal flux is the rate of heat energy transfer through a given surface, per unit time. The SI derived unit of heat rate is joule per second, or watt. Heat flux density is the heat rate per unit area. In SI units, heat flux density is measured in [W/m^2]. Heat rate is a scalar quantity, while heat flux is a vectorial quantity. To define the heat flux at a certain point in space, one takes the limiting case where the size of the surface becomes infinitesimally small.



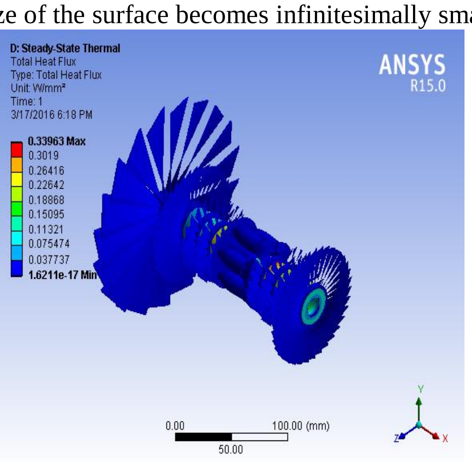


Fig.11Temperature Fig.12 Total heat flux

V. CONCLUSION:

The Deformation, Equivalent stress, equivalent strain and Fatigue stresses has been found out in the parts of turbojet engine when it is subjected to structural loads and total heat flux and temperature has been found out when it is subjected to thermal Loads at given boundary conditions.

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