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Thermal Analysis of Combustion Chamber Outer Casing of Aircraft Turbo Engine

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ABSTRACT

The ignition chamber is a turbo-engine component where fuel, complete by fuel feeding nozzles, is mixed with air which comes from the compressor. The air enters in combustion chamber with temperature comprised between 200 and 550 °C because of the heating caused by compression, so the required temperature rising in the combustion chamber is 650-1150 °C. At this temperature and pressure which is applied internally on the combustion outer casing during the combustion (fuel burning) process reduces life of the existing outer casing of combustion chamber. In this present work, 3d model of combustion outer case is generated in catiaV5 and model of component is then converted into para solid. Later, solid file of combustion outer case is imported into Ansys workbench 19.2 to perform finite element analysis. Finite element model of component is subjected to steady state thermal analysis at a temperature of 82 3K. Structural static analysis shall be performed on combustion outer case for operating internal pressure and thermal loads. Deflections and stresses are tabulated. Based on the results. Catiav5 software is used to generate 3d model and Ansys software is used to perform finite element analysis of combustion outer case.

Keywords: Job Satisfaction, Sustainable Development, Policy For Higher Education

1. INTRODUCTION

Industrial gas turbines differ from aeronautical designs in that the frames, bearings, and blading are of heavier construction. They are also much more closely integrated GE H series power generation gas turbine: in combined cycle configuration, this 480-megawatt unit has a rated thermal efficiency of 60%. with the devices they power— often an electric generator— and the secondary-energy equipment that is used to recover residual energy (largely heat).

They range in size from man-portable mobile plants to enormous, complex systems weighing more than a hundred tonnes housed in block-sized buildings. When the turbine is used solely for shaft power, its thermal efficiency is around the 30% mark. This may cause a problem in which it is cheaper to buy electricity than to burn fuel. Therefore many engines are used in CHP (Combined Heat and Power) configurations that can be small enough to be integrated into portable container configurations. Gas turbines can be particularly efficient—up to at least 60%—when waste heat from the turbine is recovered by a heat recovery steam generator to power a conventional steam turbine in a combined cycle configuration.[16][17] They can also be run in a cogeneration configuration: the exhaust is used for space or water heating, or drives an absorption chiller for cooling the inlet air and increase the power output, technology known as Turbine Inlet Air Cooling. Another significant advantage is their ability to be turned on and off within minutes, supplying power during peak, or unscheduled, demand. Since single cycle (gas turbine only) power plants are less efficient than combined cycle plants, they are usually used as peaking power plants, which operate anywhere from several hours per day to a few dozen hours per year—depending on the electricity demand and the generating capacity of the region. In areas with a shortage of base-load and load following power plant capacity or with low fuel costs, a gas turbine powerplant may regularly operate most hours of the day. A large single-cycle gas turbine typically produces 100 to 400 megawatts of electric power and has 35–40% thermal efficiency.[18]

Theory of operation

In an ideal gas turbine, gases undergo three thermodynamic processes: an isentropic compression, an isobaric (constant pressure) combustion andan isentropic expansion. Together, these make up the Brayton cycle. In a practical gas turbine, mechanical energy is irreversibly transformed into heat when gases are compressed (in either a centrifugal or axial compressor), due to internal friction and turbulence. Passage through the combustion chamber, where heat is added and the specific volume of the gases increases, is accompanied by a slight loss in pressure. During expansion amidst the stator and rotor blades of the turbine, irreversible energy transformation once again occurs. If the device has been designed to power a shaft as with an industrial generator or a turboprop, the exit pressure will be as close to the entry pressure as possible. In practice it is necessary that some pressure remains at the outlet in order to fully expel the exhaust gases. In the case of a jet engine only enough pressure and energy is extracted from the flow to drive the compressor and other components. The remaining high pressure gases are accelerated to provide a jet that can, for example, be used to propel an aircraft.

2. LITERATUTR REVIEW

Review of literature within the literature The objective of this work is to make a 3D model of the Combustion chamber outer case and study the structural and thermal behavior of the Combustion chamber outer case by performing the finite element analysis. SOLIDWORKS and 3D modeling software (UNIGRAPHICS NX) was used for designing and analysis software (ANSYS) was used for thermal and structural analysis. combustion chamber has been designed and analysis for structural and thermal behavior of well-designed modal with design calculations. The combustion chamber was studied for Nodal Temperature, Thermal Gradient, Displacement and Von MoisesStress. From the above analysis it was concluded that the combustion chamber outer case had stresses and deflections were within the allowable limits of the material. Therefore it was concluded that the combustion chamber outer case is safe under the given operating conditions. The Max Deflection .0503m observed on the combustion chamber for pressure loading conditions and thermal loads. The Max Avg. VonMises Stress observed 828Mpa on the combustion chamber for operating loading conditions.And the Yield strength of the materials tungston is 941Mpa .Hence according to the Maximum Yield Stress Theory, the VonMoises stress is less than the yield strength of the material. Hence the design of combustion chamber is safe for the above operating loads. Perform dynamic analysis on modified combustion chamber for vibrations. For that case modal analysis carried on modified combustion chamber for natural frequencies and harmonic analysis on modified combustion chamber for operating frequencies. Objective of this dynamic analysis is to get free from resonance

A turbine casing for a gas turbine comprises a casing defining the boundary of part of the turbine flow duct and formed from a plurality of segments, each segment being mounted from fixed structure by a plurality of radially extending struts. At least some of the struts are arranged to deform to allow relative thermal expansion between the hot segments and the supporting casing with at least one of the struts interposed between the deformable struts being relatively rigid.

3. OBJECTIVE

- Create a 3D model of the Combustion chamber outer case using catia v5 software and it is converted into para solid file and import into ANSYS to do finite element analysis
- Perform thermal analysis on the Combustion chamber outer case for thermal loads.
- Perform static analysis on the existing model of the Combustion chamber outer case for pressure loads and thermal loads to find deflections and stress, optimized if enquired.
- Dynamic analysis to find six modes and natural frequency, From the Modal analysis results, the natural frequencies, mode shapes and their mass participations of the
- Combustion chamber outer case are plotted and checked if any natural frequencies are present in the operating range of the Combustion chamber router case and critical frequencies are identified.
- Life estimation of outer casing of aircraft turbo engine

4. RESEARCH METHODOLOGY

The scope of this study is to create a 3D model of the combustion chamber outer case and use finite element analysis to analyze the structural, dynamic, and thermal behavior of the Combustion chamber outer case. CATIA V5 3D modelling software following was used for modelling, and ANSYS software was used for analysis

- The CATIA V5 software is used to create a 3D model of the combustion chamber outer casing, which is then converted into a parasolid file and imported into ANSYS for finite element analysis.
- For thermal loads, perform a thermal analysis on the Combustion chamber outer case.
- Perform a static analysis for pressure and thermal loads on the model of the Combustion chamber outer case to identify deflections and stress
- Perform a modal analysis to find natural frequencies.
- The natural frequencies, mode shapes of the Combustion chamber outer case are plotted using the Modal analysis results, and critical frequencies are determined if any natural frequencies are present in the working range of the Combustion chamber outer case.
- Material selected as TMS-196 the range of temperature with stand 400 to 11000C and have ultimate tensile strength is 1195MPa

5. FINITE ELEMENT ANALYSIS (FEA)

The finite element method is a powerful tool to obtain the numerical solution of wide range of engineering problem. The method is general enough to handle any complex shape or geometry, for any material under different boundary and loading conditions. The generality of the finite element method fits the analysis requirement of today's complex engineering systems and designs where closed form solutions of governing equilibrium equations are usually not available. In addition, it is an efficient design tool by which designers can perform parametric design studies by considering various design cases, (different shapes, materials, loads, etc.) and analyze them to choose the optimum design. The method originated in the aerospace industry as a tool to study stress in a complex airframe structures. It grows out of what was called the matrix analysis method used in aircraft design. The method has gained increased popularity among both researchers and practitioners. The basic concept of finite element method is that a body or structure may be divided into small elements of finite dimensions called “finite elements”. The original body or the structure is then considered, as an assemblage of these elements connected at a finite number of joints called nodes or nodal points. Applications of FEM:

The finite element method was developed originally for the analysis of aircraft structures. However, the general nature of its theory makes it applicable to wide variety of boundary value problem in engineering. A boundary value problem is one in which a solution is sought in domain or region of a body subject to the satisfaction of prescribed boundary conditions. Finite element method is the best tool in investigation of aircraft structures involving static analysis of wings, structures of rockets and missiles, dynamic analysis, response to random loads and periodic loads. In mechanical design, stress concentration problems, stress analysis of pressure vessels, dynamic analysis of mechanical linkages can be effectively dealt using finite element method. The specific application of the finite element method in the three major categories of boundary value problems, namely equilibrium of steady state or time independent problems, Eigen value problems, and propagation or transient problems. In the equilibrium problems steady state displacement or stress distribution is found for a solid mechanics problem, temperature or heat flux distribution in the case of heat transfer problem. Referring to Eigen value problems in solid mechanics or structural problem, natural frequencies, buckling loads and mode shapes are found, stability of laminar flows is found if it is a fluid mechanics problem and resonancecharacteristics are obtained if it is an electrical circuit problem, while for the propagation or transient problem, the response of the body under time varying force is found in the area of solid mechanics. Finite element method finds its application in the field of civil engineering in carrying out the static analysis of trusses, frames and bridges. The dynamic analysis of the structure is to obtain natural frequencies, modes and response of the structures to periodic loads. Nuclear engineering also uses finite element method concept in the static and dynamic characterization of its systems such as nuclear pressure vessels, containment structure and dynamic response of reactor component containment structures. Even the Biomedical engineering applies finite element method, for impact analysis of skulls. Finite element method can be applied to analysis of excavation,

Finite element Method based upon discritization of component into Finite number of blocks (elements), Finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses subdivision of a whole problem domain into simpler parts, called finite elements, and variational methods from the calculus of variations to solve the problem by minimizing an associated error function.

STEADY-STATE THERMAL ANALYSIS

Steady-state thermal analysis to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. A steady-state thermal analysis calculates the effects of steady thermal loads on a system or component. Engineers often perform a steady-state analysis before performing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis, performed after all transient effects have diminished. A steady-state thermal analysis can be performed using the ANSYS

5.1, GEOMETRY

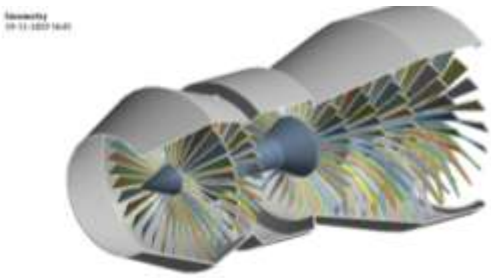


Fig 5.1, Isometric view of Outer casing of aircraft turbo engine

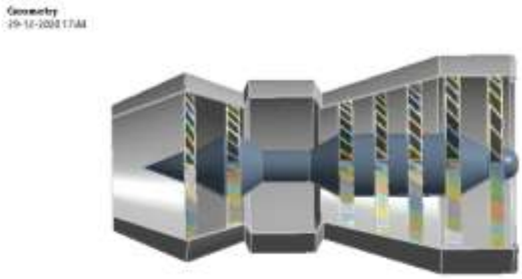
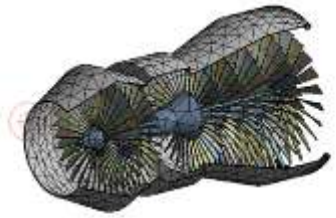


Fig 5.2, Front view of Outer casing of aircraft turbo engine

5.2.3 D Meshing FEM model

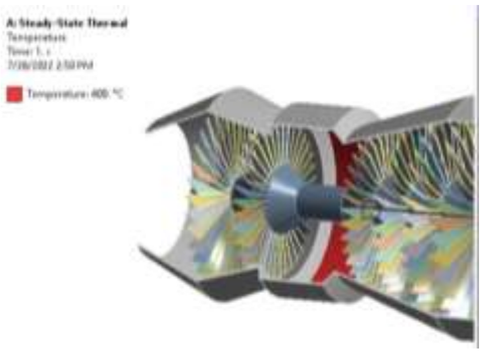
Meshing is an integral part of the computer-aided engineering simulation process. The mesh influences the accuracy, convergence and speed of the solution. Furthermore, the time it takes to create and mesh a model is often a significant portion of the time it takes to get results from a CAE solution. From easy, automatic meshing to a highly crafted mesh, FEM provides the ultimate solution. Once the best design is found, meshing technologies from FEM provide the flexibility to produce meshes that range in complexity from pure hex to highly detailed hybrid; a user can put the right mesh in the right place and ensure that a simulation will accurately validate the physical model.

1.6. Hex Dominant Meshing Method, where a free hex dominant mesh is created. This option is recommended for bodies that cannot be swept. The mesh contains a combination of tet and pyramid cells with majority of cell being of hex type. Hex dominant meshing reduced element count.



BOUNDARY CONDITION LOAD APPLIED –TEMPERATURE AND ROTATIONAL VELOCITY

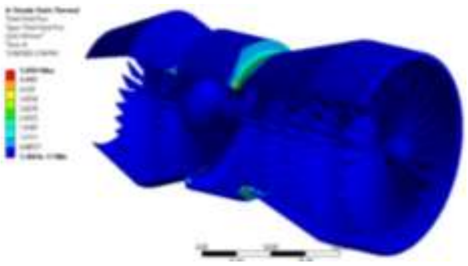
The load is in the form of rotational velocity in rad/sec.The load is applied in steps of 0%, 50%, 100%, 121%, 100%, 50%, & 0%.The 100% load is 6920rpm=724.75 rad/s. The load applied is entered in tabular data. The load is applied in the Z-Axis on the Bladed Disc assembly. The figure [4.7] is shown below.



Tabular Data

	Steps	Time [s]	Temperature [°C]
1	1	0.	0.
2	1	1.	400.
3	2	2.	500.
4	3	3.	600.
		4.	700.
		5.	800.
		6.	900.

Result and observation



Tabular Data

	Time [s]	Minimum [W/mm²]	Maximum [W/mm²]	Average [W/mm²]
1	1.	1.8273e-017	5.4484	4.5272e-002
2	2.	1.4166e-017	5.4487	5.0453e-002
3	3.	1.1484e-017	5.449	5.5954e-002
4	4.	7.1889e-018	5.4494	6.1706e-002
5	5.	1.1711e-017	5.4497	6.7683e-002
6	6.	1.3665e-017	5.4501	7.3641e-002

Fatigue analysis of wing-fuselage attachment fitting of aircraft

From the stress analysis of the rear fuselage the maximum tensile stress location is identified. A fatigue crack will always initiate from the location of maximum tensile stress. From the stress analysis it is found that such a location is at one of the rivet hole. Atypical flight load spectrum is considered for the fatigue analysis of the vertical tail skin joint. A damage tolerance design criteria and stress-life approach has been adopted for conducting a fatigue analysis. For performing fatigue calculations constant amplitude loading is preferred. In this problem variable amplitude loads will be acting but by converting them to groups of constant amplitude loading in their respective frequency. If loading is constant amplitude, than its represents the numbers of cycles until the part will failure due to fatigue. Calculation of fatigue life to crack initiation is carried out by using Good men . The various correction factors are considered in the calculation of fatigue cycles,

8. CONCLUSION

The above analysis it was concluded that the combustion chamber outer case had stresses and deflections were within the allowable limits of the material. Therefore it was concluded that the combustion chamber outer case is safe under the given operating conditions. The Max Deflection .0503m observed on the combustion chamber for pressure loading conditions and thermal loads. The Max Avg. VonMises Stress observed 828Mpa on the combustion chamber for operating loading conditions.And the Yield strength of the materials tungston is 941Mpa .Hence according to the Maximum Yield Stress Theory, the VonMoises stress is less than the yield strength of the material. Hence the design of combustion chamber is safe for the above operating loads. Perform dynamic analysis on modified combustion chamber for vibrations. For that case modal analysis carried on modified combustion chamber for natural frequencies and harmonic analysis on modified combustion chamber for operating frequencies. Objective of this dynamic analysis is to get free from resonance.Thermal analysis comparison between case1(Steel) case2(Alluminium) case 3(CFRP)was done, and maximum heat flux and minimum weight was received for CFRP material.

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