CFD SIMULATION OF GAS TURBINE COMBUSTION CHAMBER BY USING FEA TECHNIQUE

Ramsai Chigurupati[1] Tathagata Ghosh[2] Sri Srinivasa Rahul Cheemakurti[3] Vikas Sanapati[4]

ABSTRACT: The computational approach attempts to strike a reasonable balance to handle the competing aspects of complicated physical and chemical interactions of the flow. The modeling employs non-orthogonal curvilinear coordinates, second order accurate discretization, tetra grid iterative solution procedure and SST turbulence model. Accordingly, in present study an attempt has been made through CFD approach using ANSYS to analyze the flow pattern with in combustion and through air admission holes and from these the temperature distribution in the chamber walls as well as the temperature quality at the exit of combustion chamber is obtained.

Thermal analysis to determine the heat flux and temperature distribution at different materials (steel, cast iron & ceramic).

INTRODUCTION

A combustor is a component or area of a gas turbine, ramjet, or scramjet engine where combustion takes place. It is also known as a burner, combustion chamber or flame holder. In a gas turbine engine, the combustor or combustion chamber is fed high pressure air by the compression system. The combustor then heats this air at constant pressure. After heating, air passes from the combustor through the nozzle guide vanes to the turbine. In the case of a ramjet or scramjet engines, the air is directly fed to the nozzle.

A combustor must contain and maintain stable combustion despite very high air flow rates. To do so combustors are carefully designed to first mix and ignite the air and fuel, and then mix in more air to complete the combustion process. Early gas turbine engines used a single chamber known as a can type combustor. Today three main configurations exist: can, annular and cannular (also referred to as can-annular tubo-annular). Afterburners are often considered another type of combustor.

Combustors play a crucial role in determining many of an engine's operating characteristics, such as fuel efficiency, levels of emissions and transient response (the response to changing conditions such as fuel flow and air speed).

The objective of the combustor in a gas turbine is to add energy to the system to power the turbines, and produce a high velocity gas to exhaust through the nozzle in aircraft applications. As with any engineering challenge, accomplishing this requires balancing many design considerations, such as the following:

Components

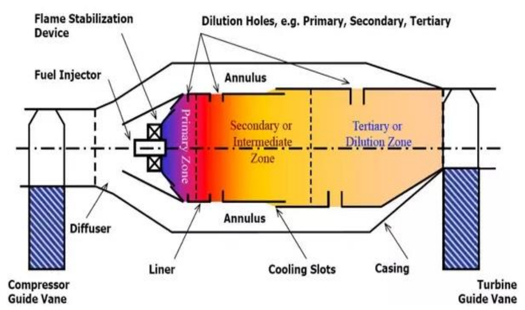
Case

The case is the outer shell of the combustor, and is a fairly simple structure. The casing generally requires little maintenance. The case is protected from thermal loads by the air flowing in it, so thermal performance is of limited concern. However, the casing serves as a pressure vessel that must withstand the difference between the high pressures inside the combustor and the lower pressure outside. That mechanical (rather than thermal) load is a driving design factor in the case.

Diffuser

The purpose of the diffuser is to slow the high speed, highly compressed, air from the compressor to a velocity optimal for the combustor. Reducing the velocity results in an unavoidable loss in total pressure, so one of the design challenges is to limit the loss of pressure as much as possible. Furthermore, the diffuser must be designed to limit the flow distortion as much as possible by avoiding flow effects like boundary layer separation. Like most other gas turbine engine components, the diffuser is designed to be as short and light as possible.

USE OF COMBUSTION CHAMBER IN GAS POWER PLANT



There are mainly two functions of combustor in a gas turbine engine. First the combustor transforms the chemical energy present in the fuel into thermal energy for expansion in turbine. Second, the combustor tailors the temperature profile of the hot gases at the exit plane to avoid the material constraints. Air from the engine compressor enters the combustor at a velocity of about 150 m/s, which is far too high for sustained combustion to take place. Hence, the air is first decelerated to a velocity of about 25 m/s in a pre-diffuser. However, the speed of burning kerosene at normal fuel-air ratios is only about 10 - 20 meters per second; hence any fuel lit even in the diffused air stream also would be blown away. Therefore, a region of low axial velocity is created in the combustor, through swirlers so that the flame will remain alight throughout the range of engine operating conditions. The high pressure air from the engine compressor is already heated to about 450Â°C. The temperature of the air is raised to about 1300 K in the combustor at constant pressure. The temperature rise in the combustor is limited by the material used in the first stage of the turbine.

Combustion serves as a vehicle to:

1. Combine and mix the air and fuel entering the combustor.
2. Ignite the mixture of fuel and air.
3. Contain the mixture during the combustion reaction, and Tailor the
4. Temperature distribution of hot gases at the exit plane.

III. LITERATURE REVIEW

A. A Review on use of Computational Fluid Dynamics in Gas Turbine Combustor Analysis and Its Scope, H. A. Bhimgade, S. K. Bhele, International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064, 6 June 2013 In this paper the CFD application and its scope, is mainly focused on gas turbine combustor (generally can or tubular, annular and tuboannular type of combustor used in gas turbines for higher efficiency). In many practical combustion applications like gas turbine and diesel engine, the combustion takes place in turbulent flow field. Therefore it is important to model the effects of turbulence and mixing interactions including all related processes either physical or chemical. In the present the emphasis is on how the turbulence leads to increased mixing in order to be used to compensate for the inaccurate prediction for the chemical reaction rate. However this has to be treated numerically and physically. Both ways are referring to the incomplete mixing process that may lead to ignite the fuel vapour before the auto-ignition delay time or out of the main reaction zone. Physically, the mixing process tends to speed up the overall reaction rate by stretching and wrinkling of the preheating zone. In addition the simulation of turbulent spray combustion remains quite a hard task because many problems may occur due to strong coupling that exists between predicted vapour mass fraction and the chemical reaction. . The experimental results and the semi empirical correlations for calculating CO, UHC, NOx, exhaust gases temperature and inner liner wall temperature as a function of different operating parameters are useful for design and further development of design, of gas turbine combustor is possible. Even with existing physical models, CFD can offer cost-effective solutions for many complex systems of interest to the power generation, aero-engines and process industries.

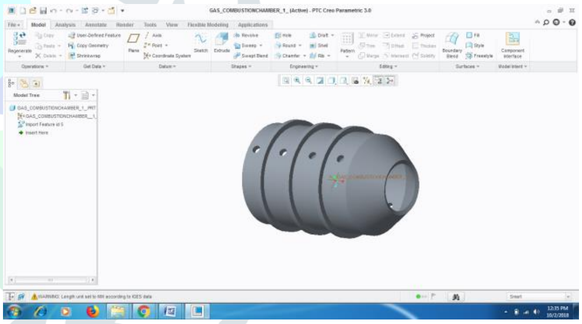
INTRODUCTION TO CAD

Computer-aided layout (CAD) is the usage of pc systems (or workstations) to resource in the introduction, change, analysis, or optimization of a design. CAD software program is used to growth the productivity of the fashion designer, improve the best of design, improve communications thru documentation, and to create a database for production. CAD output is often within the form of digital files for print, machining, or different manufacturing operations. The time period CADD (for Computer Aided Design and Drafting) is likewise used.

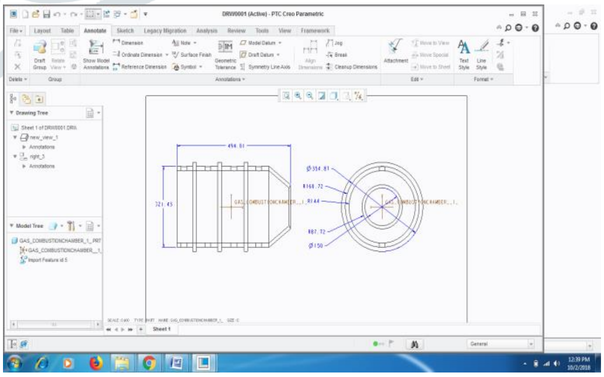
INTRODUCTION TO CREO

PTC CREO, previously called Pro/ENGINEER, is 3D modeling software used in mechanical engineering, layout, production, and in CAD drafting service companies. It became one of the first three-D CAD modeling programs that used a rule-based totally parametric machine. Using parameters, dimensions and features to seize the conduct of the product, it could optimize the improvement product in addition to the layout itself.

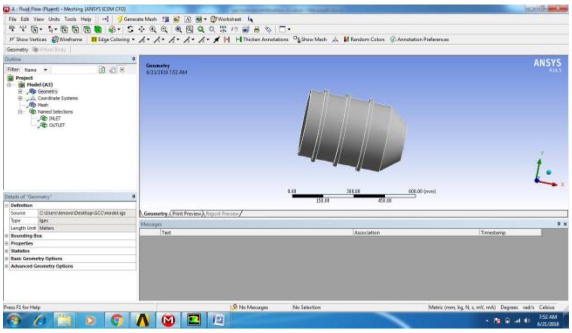
3D MODEL



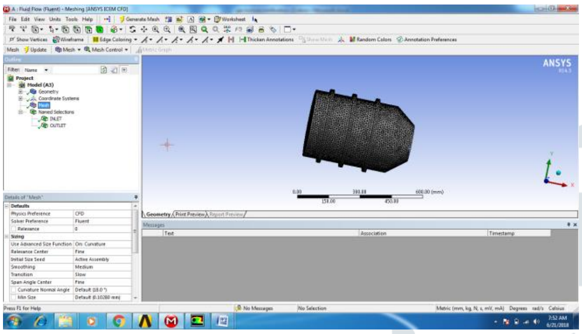
2D MODEL



Imported model

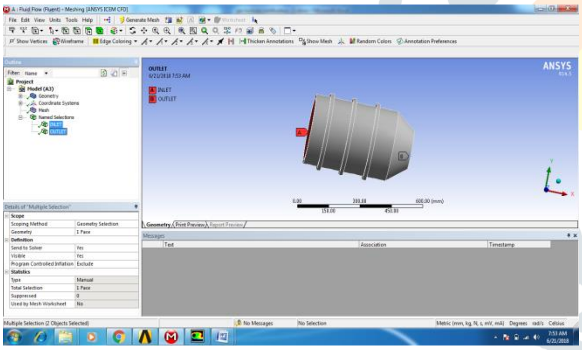


Meshed model



The meshing is done on the model with 859 number of nodes and 781 numbers of tetrahedral elements.

Inlet and outlet conditions

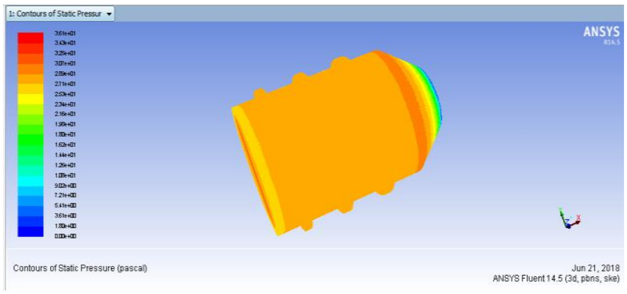


Boundary conditions are a required component of the mathematical model. Boundaries direct motion of flow. Specify fluxes into the computational domain, e.g. mass, momentum, and energy. Fluid and solid regions are represented by cell zones. Material and source terms are assigned to cell zones. Boundaries and internal surfaces are represented by face zones. Boundary data are assigned to face zones.

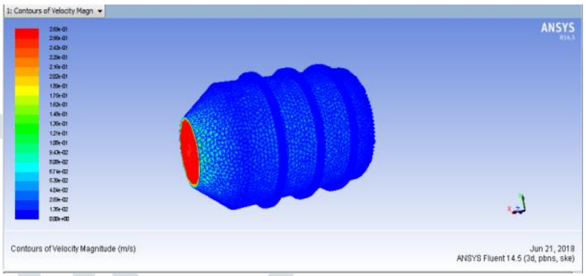
FLUID – GASOIL

PRESSURE

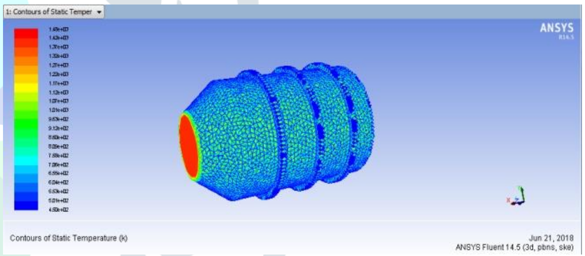
PRESSURE



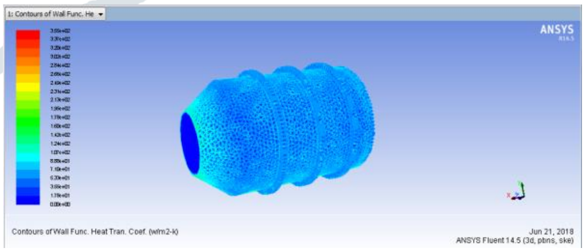
VELOCITY



Temperature



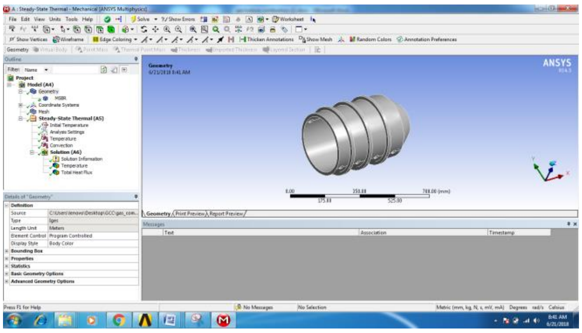
Heat transfer coefficient



THERMAL ANALYSIS OF GAS TURBINE

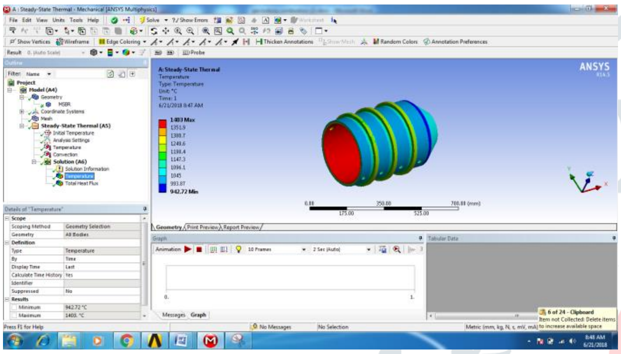
COMBUSTION CHAMBER

IMPORTED MODEL

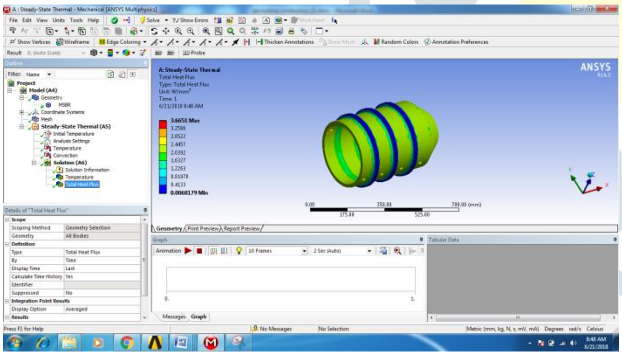


MATERIAL- CERAMICS

Temperature



Heat flux



CFD ANALYSIS RESULTS

FLUID	Pressure	Velocity	Temperature	Heat Transfer Coefficient	Mass flow rate
GASOIL	3.61E+01	2.69E-01	1.48E+03	3.5E+002	3.671E-1
ETHLEYENE	2.52E+04	1.96E+02	1.40E+03	7.22E+02	0.00456
METHYENE	2.87E+04	2.23E+021	1.41E+03	5.41E+02	0.00042

THERMAL ANALYSIS RESULTS

MATERIAL	TEMPERATURE		HEAT FLUX
	MIN	MAX	
STEEL	766.62	1403	3.0783
CAST IRON	710.56	1403	2.8882
CERAMICS	942.72	1403	3.6651

CONCLUSION

The design and analysis of gas turbine combustion chamber is based on combined theoretical and empirical approach and the design of combustion chamber is a less than exact science. This paper presents the design of combustion chamber followed by three dimensional simulations to investigate the velocity profiles, species concentration and temperature distribution within the chamber and the fuel considered as Methane (CH_4), Ethane and gasoil.

By observing the CFD analysis the heat transfer coefficient value maximum at ethane fluid when we compare methane and gasoil.

By observing the thermal analysis the heat flux value maximum at ceramic material when we compare the cast iron and steel.

So it can be concluded the better fluid ethane and ceramic material better material for gas turbine combustion chamber

REFERENCES

Ramsai Chigurupati[1]

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