Volume 6, Issue 4, April 2021 ISSN (online): 2456-0006

International Journal of Science Technology Management and Research

Available online at: www.ijstmr.com

Design And Analysis Of Gas Turbine Combustion Chamber With Various Fluids

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Abstract: 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 (CH4). The combustion chamber is designed according to the IC engine specifications and analyzed for its heat transfer rate using Finite Element analysis software ANSYS. Modeling will be done in CREO parametric software. CFD analysis to determine the pressure drop, velocity, heat transfer rate and mass flow rate with different fluids (ethanol, methanol, ethelene, propyl and gasoil).

Keywords: CREO, CFD, Combustion Chamber, Empirical approach

I. INTRODUCTION

The invention of the gas turbine engine as an aircraft power plant has been so rapid that it's hard to believe that few people have heard of this form of aircraft propulsion prior to the 1950s. A combustor is a part or region of a gas turbine, ramjet, or scramjet torment where combustion occurs. In a qualifier turbine engine, it's also known as a burner, combustion bedroom, or burn keeper. A gas turbine, also called a combustion turbine, is a type of continuous combustion, internal combustion engine. The main elements common to all gas turbine engines are:

1. An upstream rotating gas compressor
2. A combustor
3. A downstream turbine on the same shaft as the compressor.

A fourth component is often used to increase efficiency

The compression mechanism feeds violently crushing air into the combustor or combustion chamber. The combustor then heats this distressing demeanor. After heating, take note of the combustor's air. In the conjuncture of a ramjet or scramjet engines, the intelligence is soon fed to the spout. A combustor must contain and maintain steady combustion notwithstanding very high vent passage berate. To do so combustors are carefully plan to first mix and ignite the vent and fuel, and then mix in more air to ended the combustion process [1] [2].

II. COMBUSTION CHAMBER

The combustion chamber is where two main events occur: at the inlet, the fuel will mix entirely, or to a reasonable degree, with the air; and at the outlet, the fuel will mix completely, or to a sufficient degree, with the air. While some combustors blend fuel with air before burning, air and fuel should be combined before burning to ensure a smooth burn.

There are several problems that can occur:

1) Poor mixing: When fuel is not mixed enough with air, it can burn incompletely which results in increased levels of CO, soot, NOx and unburned hydrocarbons (UHC).

2) Uneven combustion: This happens when temperature of a section goes high but the neighbouring sections are colder, thus this can result in extra thermal stresses. Thermal stresses may in time lead to material fatigue and failure.

3) Environment: incompletely burned gases or unburned hydrocarbons (UHC) can poison the environment. UHC, NOx and soot are important factors for each burning device. The design should lower them as much as possible.

4) Economy: With increasing price of oil, it is important that gas turbines have high efficiency and therefore low fuel consumption. One of the most important parts, in order to achieve high efficiency, is the combustion chamber. 5) Above factors shows the importance of combustion chambers in gas turbines**.**

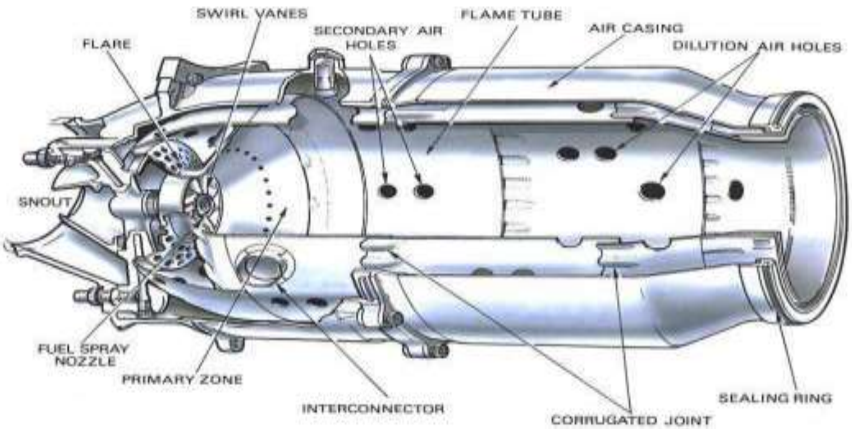

Fig -1 Combustion Chamber

A **combustor** is a component or area of 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.

Fundamentals of Combustor-:

a. Completely combust the fuel. Otherwise, the engine wastes the unbent fuel and creates unwanted emissions of un burnt hydrocarbons, carbon monoxide (CO) and soot.

b. Low pressure loss across the combustor. The turbine which the combustor feeds needs high pressure flow to operate efficiently.

c. The flame (combustion) must be held (contained) inside of the combustor. If combustion happens further back in the engine, the turbine stages can easily be overheated and damaged.

d. Uniform exit temperature profile. If there are hot spots in the exit flow, the turbine may be subjected to thermal stress or other types of damage. Similarly, the temperature profile within the combustor should avoid hot spots, as those can damage or destroy a combustor from the inside.

III. COMBUSTION PROCESS

Air from the engine compressor enters the combustion chamber at a velocity up to 500 feet per second, but because at this velocity the air speed is far too high for combustion, the first thing that the chamber must do is to diffuse it, i.e. decelerate it and raise its static pressure. Since the speed of burning kerosene at normal mixture ratios is only a few feet per second, any fuel lit even in the diffused air stream, which now has a velocity of about 80 feet per second, would be blown away. A region of low axial velocity has therefore to be created in the chamber, so that the flame will remain alight throughout the of a combustion chamber can vary between 45:1 and130:1, However, kerosene will only burn efficiently at, or close to, a ratio of 15:1, so the fuel must be burned with only part of the air entering the chamber, in what is called a primary combustion zone. This is achieved by means of a flame tube (combustion liner) that has various devices for metering the airflow distribution along the chamber.

Approximately 20 per cent of the air mass flow is taken in by the snout or entry section (fig.4).Immediately downstream of the snout are swirl vanes and a perforated flare, through which air passes into the primary combustion zone. The swirling air induces a flow upstream of the centre of the flame tube and promotes the desired recirculation. The air not picked up by the snout flows into the annular Space between the flame tube and the air casing.

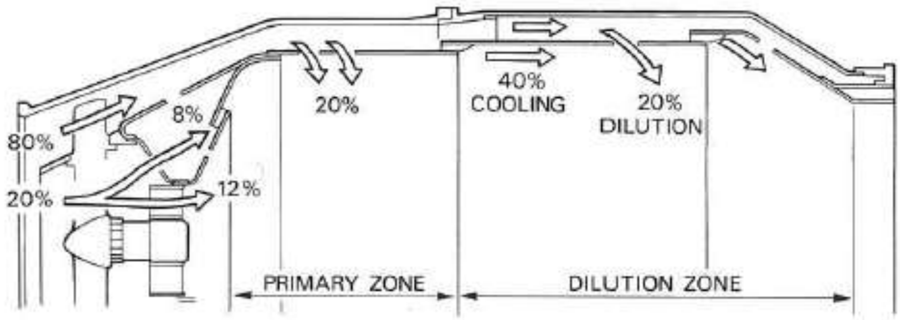

Fig- 2 Airflow Distribution along the chamber

Through the wall of the flame tube body, adjacent to the combustion zone, are a selected number of secondary holes through which a further 20 per cent of the main flow of air passes into the primary zone. The air from the swirl vanes and that from the secondary air holes interacts and creates a region of low velocity recirculation. This takes the form of a toroidal vortex, similar to a smoke ring, which has the effect of stabilizing and anchoring the flame (fig,5).The re-circulating gases hasten the burning of freshly injected fuel droplets by rapidly bringing them to ignition temperature.

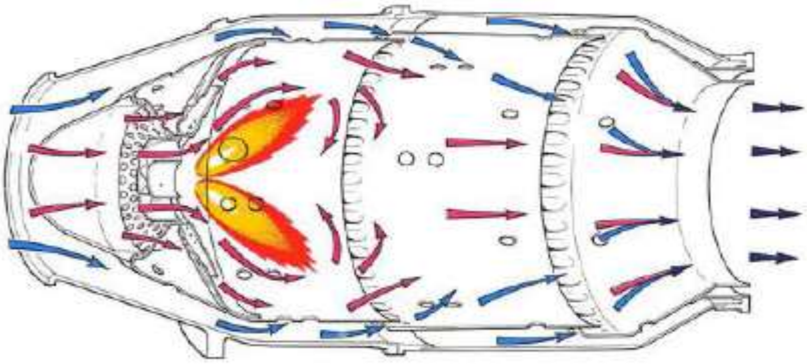

Fig- 3 Smoke Ring

It is arranged that the conical fuel spray from the nozzle intersects the recirculation vortex at its centre. This action, together with the general turbulence in the primary zone, greatly assists in breaking up the fuel and mixing it with the incoming air. The temperature of the gases released by combustion is about 1,800 to 2,000 deg. C., which is far too hot for entry to the nozzle guide vanes of the turbine. The air not used for combustion, which amounts to about 60 per cent of the total airflow, is therefore introduced progressively into the flame tube. Approximately a third of this is used to lower the gas temperature in the dilution zone before it enters the turbine and the remainder is used for cooling the walls of the flame tube. This is achieved by a film of cooling air flowing along the inside surface of the flame tube wall, insulating it from the hot combustion gases. A recent development allows cooling air to enter a network of passages within the flame tube wall before exiting to form an insulating film of air, this can reduce the required wall cooling airflow by up to 50 per cent. Combustion should be completed before the dilution air enters the flame tube.

IV. CFD ANALYSIS

By observing the CFD analysis the pressure drop, velocities and heat transfer rate values are increasing by increasing the velocity. The thermal analysis is to determine the heat flux of the combustion chamber the heat flux more for steel compare with cast iron material.
So it can be concluded the heat transfer rate more for PROPYL fluid, when heat transfer rate will more than the engine efficiency will increase.

- CFD Analysis Results Table

Fluids	**Pressue (pa)**	**Velocity (m/s)**	**Heat transfer coefficient (w/m2-k)**	**Heat transfer rate(W)**	**Mass flow rate(kg/s)**
ethanol	$3.07e^{+06}$	$1.48e^{+02}$	$7.90e^{+04}$	3172116.5	15.739029
methanol	$2.87e^{+06}$	$1.69\ e^{+02}$	$8.09e^{+04}$	2666271.2	11.90834
ethelene	$8.41e^{+03}$	$1.59\ e^{+02}$	$6.99\ e^{+02}$	1297.443	0.018528
propyl	$3.71e^{+06}$	$1.76\ e^{+02}$	$2.09\ e^{+05}$	3400758.7	13.964752
Gas oil	$1.195e^{+07}$	$1.586\ e^{+02}$	$3.578\ e^{+04}$	2324893.4	13.03038

- VELOCITY 150m/s

fluids	Pressure(pa)	Velocity (m/s)	Heat transfer coefficient (w/m2-k)	Heat transfer rate(W)	Mass flow rate(kg/s)
ethanol	$4.6e^{+06}$	$2.0e^{+02}$	$9.780e^{+04}$	3634251.9	17.86530
methanol	$4.565e^{+06}$	$1.960e^{+02}$	$1.002\ e^{+05}$	3884644.9	17.865326
ethelene	$1.402e^{+04}$	$1.904\ e^{+02}$	$7.462\ e^{+02}$	2815.9748	0.022484
propyl	$5.997e^{+06}$	$1.851\ e^{+02}$	$2.479\ e^{+05}$	4448207.7	19.316803
Gas oil	$1.102e^{+0}$	$1.877e^{+2}$	$4.261\ e^{+04}$	3434600.6	19.312317

- **Thermal Analysis**

MATERIAL	**TEMPERATURE(k)**		**HEAT FLUX(W/mm^2)**
	MIN	**MAX**	
STEEL	421.07	500	1.5307
CAST IRON	`410.52	500	1.4979

V. RESULTS AND DISCUSSION

The complete combustor design using the initial parameters has been evidently discussed in this paper. this is more sophisticated design approach which can be used for the preliminary design. By using this practise a practical design can be illustrated. Based on theoretical calculation and obtained results, the design point combustor exit temperature was achieved within 96% efficiency. Thus the design is capable of reaching higher temperatures.

CONCLUSION

The design was efficaciously calculated and modeled. The mandatory simpler model for exploration was also created. Then the model was aerodynamically analyzed at design point and the geometry was enhanced based on the results. This has delivered one of the most efficient combustion chamber design that can be used in the gas turbine engine

REFERENCE

1. Aircraft Propulsion B.Y. Farooki
2. Modeling of Combustion Systems: A Practical Approach by Joseph Colannino . Hand, H. Mannila, P. Smyth, “Principles of Data Mining, Prentice Hall of India, 2004
3. The JET ENGINE – rolls- royce
4. Modeling of combustion systems
5. CFD analysis of rocket engine combustion chamber by- J. steelant