Design and Performances Analysis of Micro Turbine in Turbojet Engines

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Abstract : The design of a can combustion chamber in a gas turbine engine is the backbone of this paper. It is specifically designed for a low bypass turbofan engine in a jet aircraft. The combustion chamber is positioned in between the compressor and turbine. It has to been designed based on the pressure, enthalpy addition process. The present methodology deals with the increasing efficiency of jet engine by using Micro turbine. Basically micro turbine is used for producing energy in aircraft engine, by controlling the sensors processing energy scavenging. The combustion chamber result is calculated with micro turbine and without micro turbine. To comparedthe result for final flow of some parameters like the pressure, velocity and temperature. The whole combustion chamber is modeled using CATIA V5R20, the modeling software and presented. The model is then analyzed using various parameters at various stages and levels to determine the optimized design. The aerodynamics flow characteristics are simulated numerically by mean of ANSYS 14.0 software suite. The air fuel mixture, combustion turbulence, thermal and cooling analysis is carried out. The analysis is performed at combustion chamber flow output then compared them with micro turbine and without micro turbine.

IndexTerms- **Combustion chamber, Turbine, Microturbine, Compressor and Efficiency.**

I. Introduction

The turbojet is an, air breathing jet engine typically used in aircraft. The gas turbine has an air inlet, a compressor, a combustion chamber and a turbine. Micro turbines are relatively new distributed generation technology being used for stationary energy generation application. A micro turbine has greater efficiency while comparing with other technologies.

MICROTURBINES: The micro turbine is optimized for a realistic combination of turbine inlet temperature, the recuperation rate and pressure ratio. The stimulated electrical efficiency is 45%. Improved efficiency of combined heat and power system will significantly decrease the emission and the operating cost of decentralized heat and electricity production. Cost effective, compact and environmental friendly micro and small scale turbine systems with high electrical efficiency will have an opportunity to successfully compete against reciprocating engines.

ANALYSIS: The temperature, velocity and pressure get increased in every aspect. The pressure gets increased so that the consumption of fuel is very low.

II. Design

Description of combustion chamber

A Combustion process increases the internal energy of a gas, which translates into an increase in temperature, pressure, or volume depending on the configuration. It is also known as a burner or flame holder. In a gas turbine engine, the combustor or combustion chamber is fed high pressure air by the compression system.

Description of micro turbine

Micro Turbines are small combustion turbines approximately the size of a refrigerator with outputs of 25 kW to 500 kW. They evolved from automotive and truck turbochargers, auxiliary power units for airplanes, and small jet engines and are comprised of a compressor, combustor, turbine, alternator, recuperator and generator.

Design of combustion chamber and microturbine

Dimensions are referred from ASTM (American Society of Testing and Materials) and designed in CATIA V5R20.

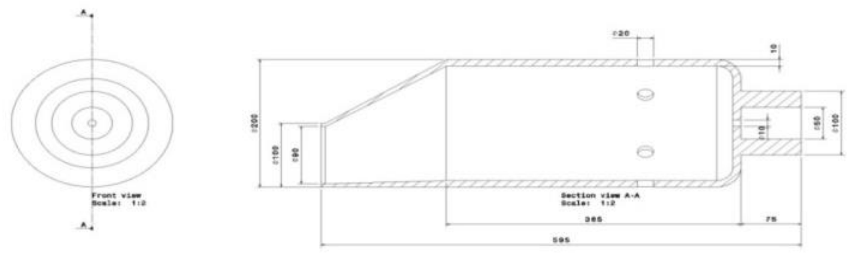

Fig.1 2-D diagram of Combustion Chamber

The design of combustion chamber is shown in Figure 1 are done using the CATIA V5R20 software. Two dimensional parameters are,

Area of inlet = 200*90

Area of combustion chamber = 385*200

Area of outlet = 75*100

Thickness of outer layer =10

All dimensions are (mm) of two dimensional view of combustion chamber. The size and shape of the combustion chamber depends upon the material to be in a manufacturing process. The nozzle used in this type will reduce the outgoing air to the atmosphere and fuel consumption.

The part design of combustion chamber and micro turbine are followed below:

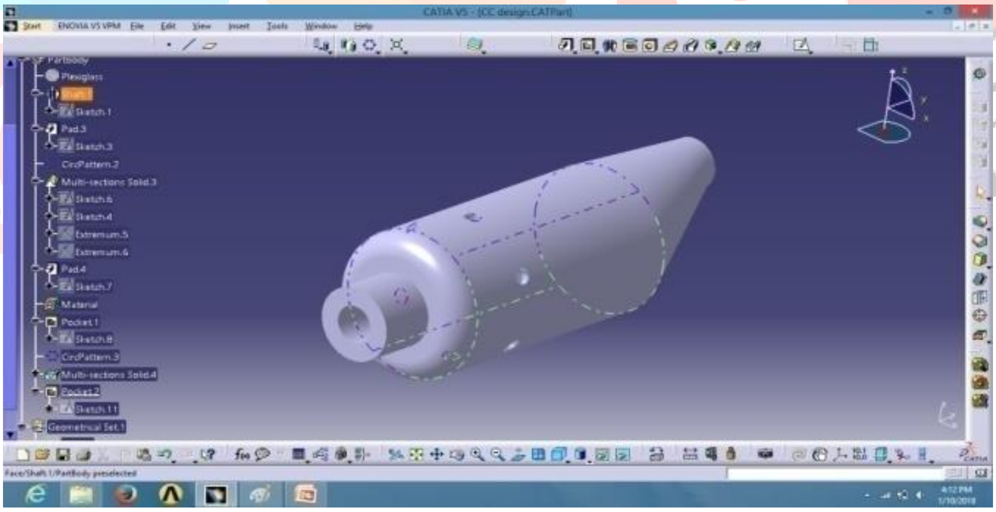

Fig.2 3-D Design of Combustion Chamber

The figure 2 represents the three dimensional view of combustion chamber design model has been done in CATIA software.

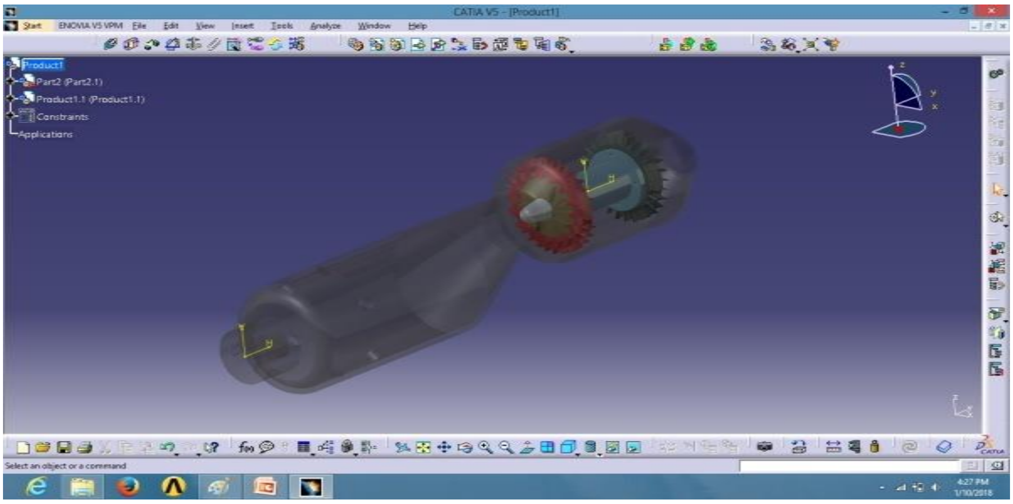

Fig.3 3-D Design Assembly of Combustion Chamber with Micro turbine

The figure 3 represents the design is the three dimensional view of total body assembly of Combustion Chamber with Microturbine designed in CATIA V5R20. The microturbine which is attached to the combustion chamber will reduce the fuel consumption it is also has an advantage over an after burner. The nozzle design of this combustion chamber will collect the air flow completely to the microturbine to avoid wastage of air and increase the velocity.

III. PROPOSED SYSTEM

In computational solution of partial differential equations, meshing is a discrete representation of the geometry that is involved in the problem. Essentially, it partitions space into elements (or cells or zones) over which the equation can be approximated. In addition, meshes also find extensive use in the analysis of geographical and cartographic data.

S.NO	DESCRIPTION	MESH TYPE	NO. OF NODES	NO.OF NODAL ELEMENTS
1	Combustion Chamber	Tetrahedral	241101	14915
2	Combustion chamber with Microturbine	Tetrahedral	1189174	77991

Table 1: Details of Meshing

The table 1 shows that the details of meshing for design and analysis of microturbine.

The meshing of a combustion chamber is carried out in ANSYS software and the type of mesh selected is tetrahedral type and the mesh result for nodes & nodal elements are 241101 & 14915. The meshing of a combustion selected is combustion chamber with microturbine is carried out in ANSYS software and the type of mesh selected is tetrahedral type and the mesh result for nodes & nodal elements are 1189174 &77991.

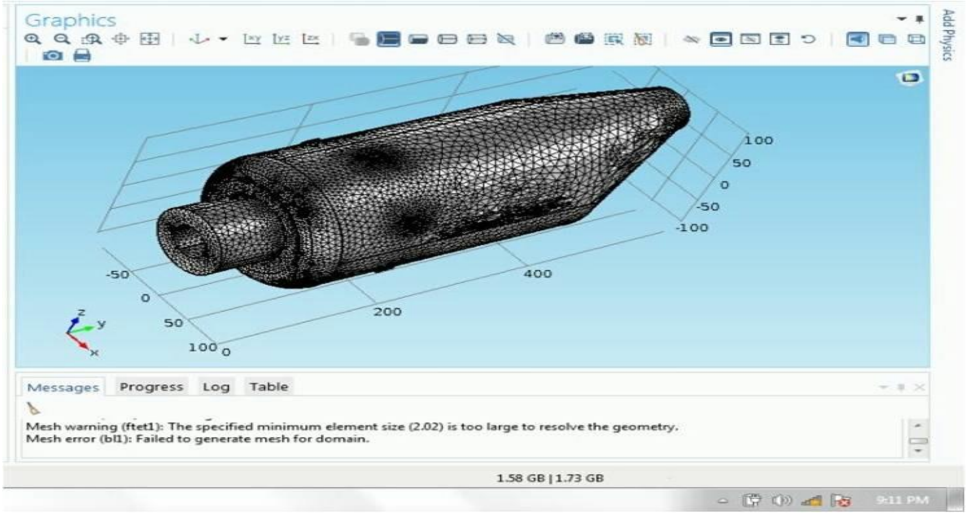

Fig.4 Meshing of Combustion Chamber

The figure 4 represents the meshing of an Combustion Chamber. It is done using ANSYS 14.0 software. The quadrilateral type of mesh has been used in this design to give proper numerical value.

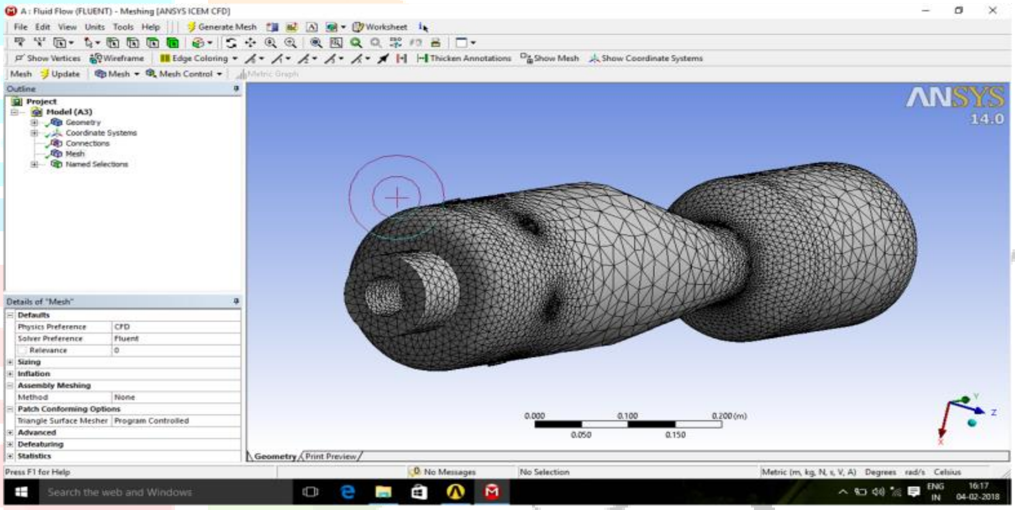

Fig.5 Meshing of Combustion Chamber with Microturbine

The figure 6.2 represents the meshing of a Combustion Chamber with Microturbine. The design was meshed using ANSYS 14.0 software. The quadrilateral type of meshing has been used in this design to give proper numerical value.

IV. Result and Discussion

Design and Analysis of Combustion Chamber with Microturbine has been carried out by (ANSYS software) for various parameters like velocity, temperature and pressure. The Analysis is carried out by comparing the results for Combustion Chamber with Microturbine and without Microturbine.

The table 2 shows the boundary condition for the design and performances analysis of microturbine analysis.

Boundary condition

Fluid Type	AIR
Mach number (M)	3
Pressure(P) in Pascal	2.527 × 103
Density (ρ) in kg/m3	4.064 ×10-2
Mass flow rate in Kg/s	0.001
Temperature in K	300

Table 2: Boundary Conditions of Mesh

The table 2 shows the boundary condition for the design and performances analysis of microturbine analysis.

Convergance plot

Case (i) Combustion Chamber

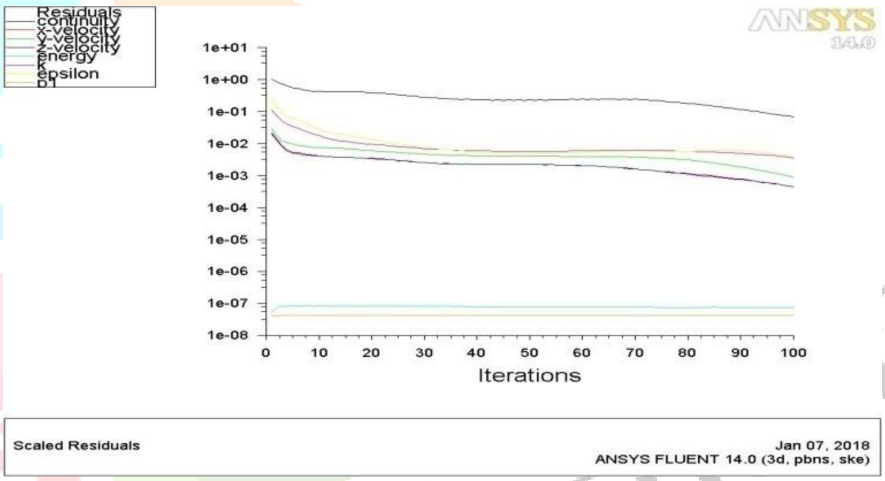

Fig. 6 Residual convergence for Combustion Chamber

Case (ii) Combustion Chamber with Microturbine

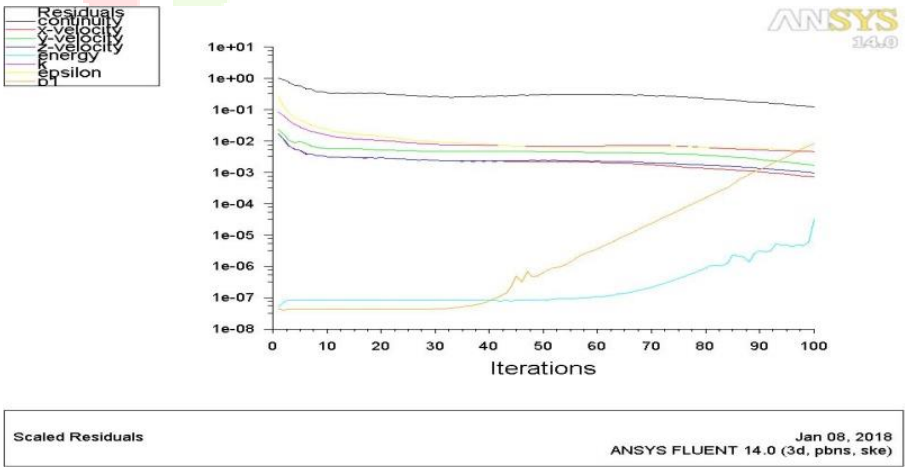

Fig. 7 Residual convergence for Combustion Chamber with Microturbine

The CFD results were analyzed after the solution is convergence for both the cases. The convergence plots of the residuals are shown in figure 6 and 7. The convergence plot indicates that solution is converged.

Temperature distribution

Case (i): Temperature of Combustion Chamber

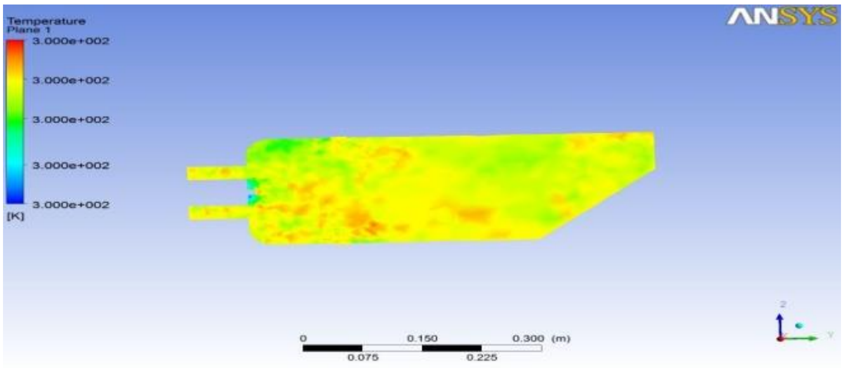

Fig. 8 Contours of Temperature for Combustion Chamber

Case (ii): Temperature of Combustion Chamber with Microturbine

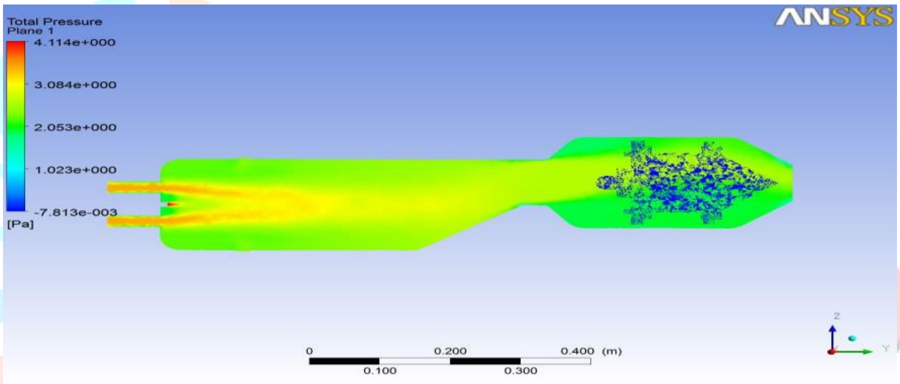

Fig. 9 Contours of Temperature for Combustion Chamber with Microturbine

When compared to combustion chamber with microturbine has greater temperature than combustion chamber without microturbine.

pressure distribution

Case (i) Pressure of Combustion Chamber

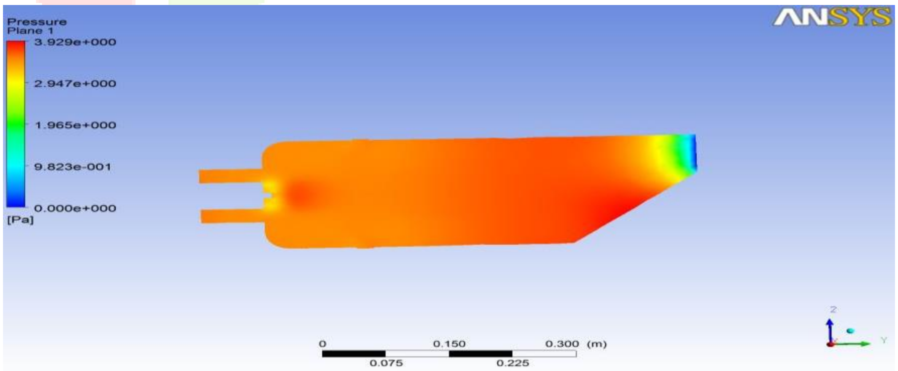

Fig. 10 Contours of Pressure for Combustion Chamber

Case (ii) Pressure of Combustion Chamber with Microturbine

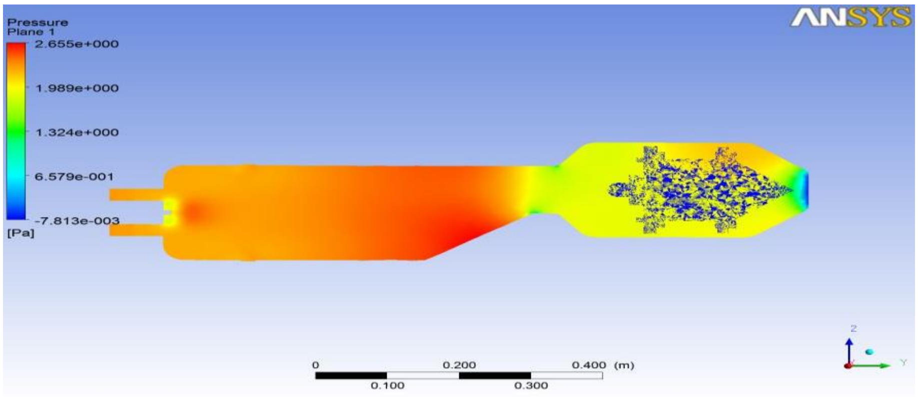

Figure 11: Contours of Pressure for Combustion Chamber with Microturbine

Pressure in the combustion chamber with microturbine decreases when compared to combustion chamber without microturbine.

velocity distribution

Case (i) Velocity of Combustion Chamber

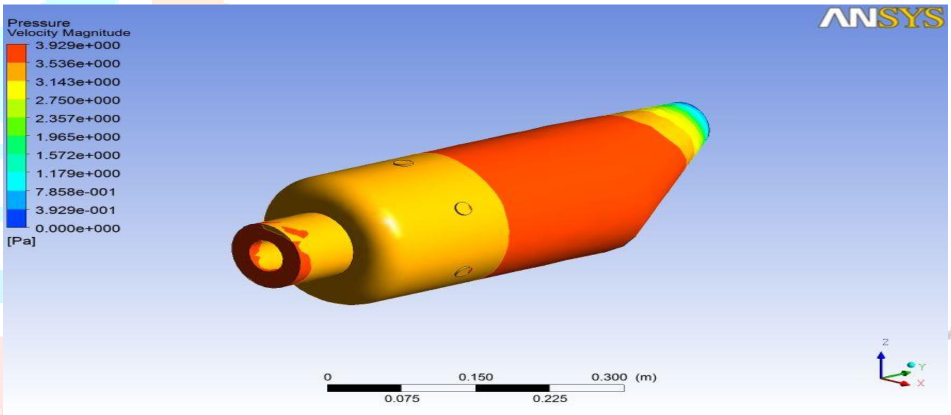

Fig. 12 Contours of Velocity for Combustion Chamber

Case (ii) Velocity of Combustion Chamber with Microturbine

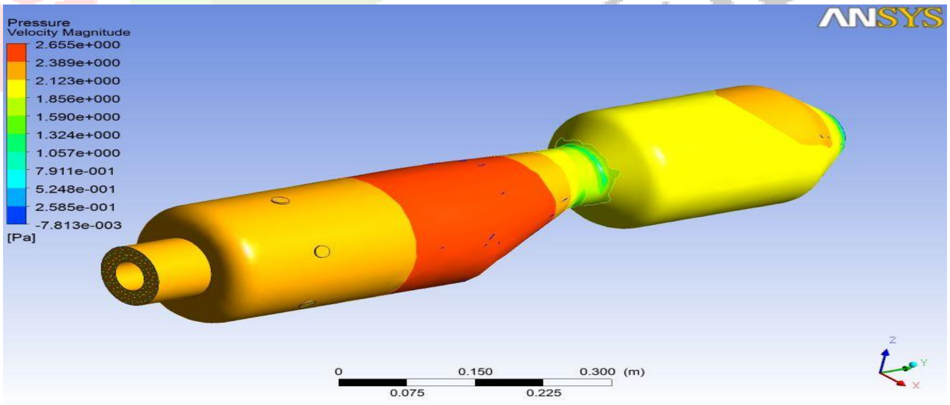

Fig. 13 Contours of Velocity for Combustion Chamber with Microturbine

When compared to combustion chamber with microturbine has higher velocity than combustion chamber without microturbine.

V. CONCLUSION

In this project the design of combustion chamber with microturbine is designed using CATIA V5R20 and analysis done using ANSYS 14.0 software. Dimension and design data of Combustion Chamber was taken from the reference [1]. Comparison of various parameters like pressure, temperature and velocity has been done both the conditions using ANSYS 14.0 for Combustion chamber and Combustion chamber with Microturbine. One of the suitable method for increasing efficiency by placing the microturbine with the combustion chamber. Finally, we conclude that the combustion chamber with microturbine have more pressure, temperature, velocity and efficiency, than the normal combustion chamber.

VI. FUTURE WORK

The project is carried out only with the mach number of 3 where as other mach numbers can also be carried out. The numerical stimulations can be carried out for temperature, pressure, velocity and efficiency where as other parameters are like density, speed, viscosity, etc, can also be calculated. The dimensions of the combustion chamber with microturbine can be changed for different configuration can also be studied.

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REFERENCES

[1] Priyank Shah, Samir Mehta, RushikeshGaikwad and NitinPandey (2016) "Numerical Analysis of Combustion Chamber with Methane Air Mixture for Different Inlet Air Velocities", International Journal of Scientific and Engineering Research, Volume 7, Issue 4, April (2016), ISSN 2229-5518.

[2] K. C. Goli, S. V. Kondi, V. B. Timmanpalli (2015) "Principles and Working of Micro Turbine", Department of Mechanical Engineering, S. E. S. Polytechnic, Solapur, MSBTE, Maharashtra, India, Special Issue, IJIERT February 2015.

[3]Robert Zogg, John Bowman, Kurt Roth, James Brodrick (2007) "Using Microturbines", Associate Member of ASHRAE (American Society of Heating Refrigerating and Air-Conditioning Engineers) April (2007).

[4] Manas Kumar Padhi, "Micro-Turbine Generator System", Department of Electrical and Electronics Engineering, 0501209277.

[5] P. J. Stewart, "Combustion Efficiency in Gas Turbine Engines", Study of Temperature Distribution with Rhodium-Platinum Thermocouple Probes, Aero Engine Division, Rolls-Royce Limited, Derby.

[6] Amanda Kalish, Elyssa Morrow, Michael Powers, Stephen Rose and Professor D. J. Olinger, Advisor, "Design of a Micro-Turbine for Energy Scavenging from a Gas Turbine Engine", Degree of Bachelor of Science, Worcester Polytechnic Institute.

[7] ChaoukiGhenai (2010) "Combustion of Syngas Fuel in Gas Turbine Can Combustor", Department of Ocean and Mechanical Engineering, College of Engineering and Computer Science, Florida Atlantic University, 777 Glades Road, 36-177, Boca Raton, FL 33134, USA. Hindawi Publishing Corporation, Advances in Mechanical Engineering, Volume 2010, Article ID 342357, DOI: 10.1155/2010/342357.

[8] SibasishPatnaik and AnkurSachdev, "Design and Development of Micro Turbine", Department of Mechanical Engineering, National Institute of Technology, Rourkela (2009).

[9] Prof. Q. H. Nagpurwala, "Design of Gas Turbine Combustors", M. S. Ramaiah School of Advanced Studies, Bengaluru.

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