Original Research Paper

Volume-8 | Issue-6 | June-2018 | PRINT ISSN No 2249-555X

Engineering

COMPUTATIONAL INVESTIGATION ON MICRO GAS TURBINE ENGINE WITH VARIOUS SWIRLER CONFIGURATIONS

Dinesh Bharathi M	Student, Department of Aeronautical Engineering, Nehru Institute of Engineering and Technology, Coimbatore, India.
H Revanth*	CFD Analyst, Global Nodes Engineering Solutions, Chennai, India *Corresponding Author
Dr. P. Maniarasan	Principal, Nehru Institute of Engineering and Technology, Coimbatore India.

ABSTRACT In conventional gas turbine engine there are so many difficulties to obtain proper combustion. A swirler is used for mixing air and fuel for combustion and stabilizing the flame. In order to stabilize the flame, the incoming high-speed air must be decelerated to a velocity below the turbulent flame speed. The flame stabilizes along the locus of points where the air velocity is equal to the flame speed. There are so many ways to mix fuel air and stabilize the flame for proper combustion that will not only improve the fuel efficiency by combustion of fuel but also reduces the emission and pollution significantly by creating the internal and central recirculation zone. This paper presents the study of micro gas turbine engine with different configurations of swirlers. The incorporation of swirler can divide stream flow into multiple streams to obtain high turbulence inside the combustor for proper mixing of air with fuel and efficient performance in combustion and also swirler is used to stabilize flame by producing high turbulence. In this micro combustor we use inner and outer annulus to induce turbulence intensity and to stabilize the flame inside the combustor. In this present numerical study, a conventional micro gas turbine engine is considered and the swirler configurations are modified for better swirling performance. Also the porous media is used instead of swirler to improve the mixing performance. The CFD predictions prove that the effect of swirling is completely affected by changing the swirler hole configurations. Also the porous media can be used for better swirling effects.

KEYWORDS : Swirler, CFD, Porous Media, Turbulent Intensity

1. INTRODUCTION

Introduction In a micro gas turbine engine different types of swirlers are used to produce more swirling effect and proper mixing of air with combustion fuel. There are axial type of swirlers, tangential type of swirlers and rotating type of swirlers used in the micro gas turbine engine. The tangential inlet swirl is especially used for its feature of low pressure loss and swirl intensity.The rotating pipe swirlers are not used in combustion because it hasn't found wide application on the practice. For the study of the axial guide vane it is important to take some data from the pre performed experiments. In these experiments PIV method is used to analyze the flow area. From experiments it can be seen that the velocity with average magnitude for the sufficient time period. The reporting cross section lies downstream with respect to the swirl generator but from the sudden expansion it is still at upstream. The results of these data suggest no reverse flow. In this research work different types of swirlers are considered and computationally analyzed for better swirling performance.

2. COMPUTATIONAL METHODOLOGY

This chapter explains the overall methodology carried out during the project execution of Combustor-Swirler simulation. It includes the CAD model preparation, Domain Discretisation, Boundary Conditions and Solution Convergence.

2.1 CAD Modelling

Figure 1 shows the complete CAD model details of micro gas turbine combustor used for investigating the Swirler effects. In this micro gas turbine engine a convergent – divergent conical solid is used to increase the mixing enhancement and combustion performance. There is two annulus one is inner annulus with extraction part attached and another one is outer annulus. Both annulus has various diameter holes for dilution.

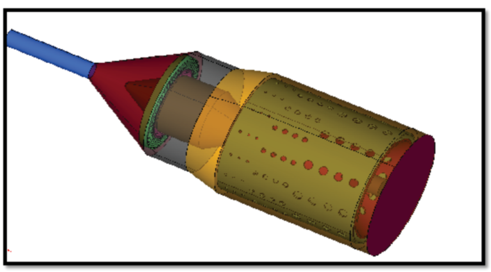

Fig -1 Micro Gas Turbine Model used for present analysis Name of the figure

Five different configurations of swirlers have been generated using standard CAD tool. The diameter of the Swirler is taken as 115 mm and the outer casing diameter of micro gas turbine is kept as 152 mm. Total length of micro gas turbine engine is 449mm.

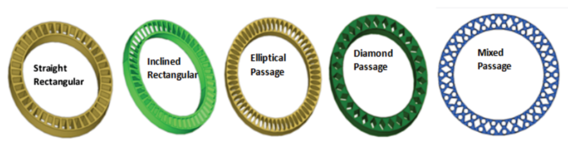

Fig -2 Swirler Types used for the present computational investigation

2.2 Meshing

The modelled flow domain with Swirler is discretised with triangular elements in HYPERMESH. The Swirler profiles are captured with a minimum element size of 1 mm and the combustor casing is meshed with an element size of 3mm. The inner and outer annular passages are meshed with an average element size of 2mm and the mesh refinement is carried out with a size of 0.5 mm near the holes. Figure 3 shows the surface meshing of the micro gas turbine engine inner and outer annulus. Figure 4 shows the cut sectional view of the volume mesh inside the flow domain along the micro gas turbine engine. The total mesh count used for this simulation is around 7.7 millions tetra elements with a node count of 1.4 millions.

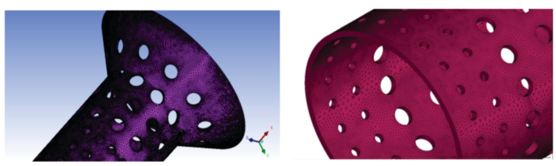

Fig -3 Inner and Outer Annulus of the Micro Gas Turbine Engine

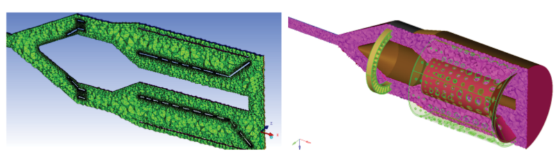

Fig -4 Volume Tetra Mesh - Cut Sectional View along the flow

2.3 Physics Definition

The boundary conditions to the meshed file are applied in Ansys Fluent. The flow is considered as a steady flow and a pressure based coupled solver is invoked in order to simulate the swirling effects. The inlet is mentioned with 'Velocity Inlet' boundary conditions and the outlet is mentioned with 'pressure outlet' conditions. Swirler and Annulus surfaces are given with 'Standard Wall' boundary conditions. Atmospheric air is used to simulate the flow. The inlet velocity is given as 70 m/s and the outlet gauge pressure is maintained with 0 Pa. The standard atmospheric conditions are chosen as reference.

3. RESULTS AND DISCUSSIONS

After the solution is converged the contours and plots are obtained using Ansys-CFD post processing. The main objective is to get the maximum swirling effect with high turbulence without any pressure losses. Hence, the static pressure and dynamic pressure contours are compared along with turbulence. The % intensity of turbulence significantly varies according to various shapes of turbulence passages. In the end of the simulation all five configuration of swirler value is predicted with contours. In all five configurations straight swirler configuration is kept as base line of this simulation. Now we going to compare all other configurations with the base line configurations. For proper combustion inside the combustion chamber there must be low dynamic pressure and high static pressure and air fuel mixture ratio must be good enough for combustion. Inserting a swirler is creates good turbulence effect inside the turbine and the swirling flow we can obtain for good combustion and flame stability inside the combustion chamber. Figure 5 shows the static pressure , dynamic pressure and turbulent intensity over the swirler configuration.

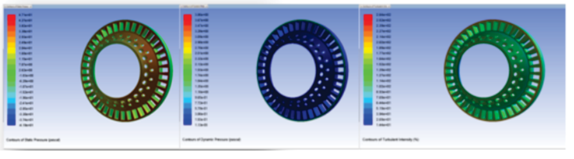

Fig -5 Static Pressure, Dynamic Pressure and Turbulence Intensity contours of straight baseline swirler model

Figure 6 shows the static pressure variations over the swirler configurations. It can be noted that the static pressure It describes that the comparison images of static pressure for four configuration swirler. Static pressure for corresponding four configuration is for inclined is 124pascal, for elliptical is 37.33pascal, for diamond is 52.6pascal and for hybrid swirler is 47.1pascal.

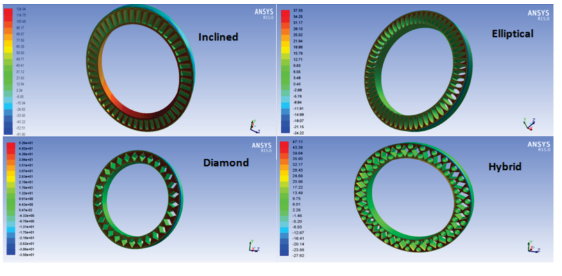

Fig -6 Static Pressure Variations over the Swirler Configurations

Figure 7 describes that the comparison images of static pressure for four configuration swirler with guider. Static pressure for corresponding four configuration is for inclined is for inclined is 159pascal, for elliptical is 58.42pascal, for diamond is 52.6pascal and for hybrid swirler is 47.1pascal.

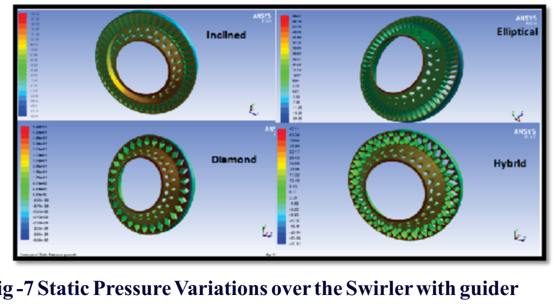

Fig -7 Static Pressure Variations over the Swirler with guider

4. CONCLUSIONS

The numerical simulation on the effect of swirler configurations in a micro gas turbine engine has been simulated successfully.The numerical results predict the flow and turbulence nature accurately and give significant variations in the results.It is observed from the results that the turbulence intensity produced in the diamond with hole configuration is more effective and significantly increases the swirl flow.The static pressure inside the combustion chamber annulus is reasonably maintained without any pressure losses in both diamond and hybrid configurations while comparing with other swirler configurations.The hybrid configuration reveals a promising value for dynamic pressure as low dynamic pressure if satisfactory for good combustion process

5. REFERENCES

[1] Ian A. Waitz, Gautam Gauba and Yang-Sheng Tzeng "Combustors for Micro-Gas Turbine Engines", Received October 14, 1996; Revised September 11, 1997; Online December 04, 2007)

[2] Yongqiang Fu, San-Mou Jeng and Robert Tacina,"characteristics of the Swirling Flow Generated by an Axial Swirler" Reno, Nevada, USA, June 6–9, 2005

[3] H.L. Cao, J.L. Xu, "Thermal performance of a micro-combustor for micro-gas turbine system", 5, May 2007

[4] M.R. Johnson, D. Littlejohn, W.A. Nazeer, K.O. Smith, "A comparison of the flow fields and emissions of high-swirl injectors and low-swirl injectors for lean premixed gas turbines", January 2005

[5] Alberto Traverso, Aristide F. Massardo, Riccardo Scarpellini, "Externally Fired micro-Gas Turbine: Modelling and experimental performance", November 2006

[6] P.A. Pilavachi, "Mini- and micro-gas turbines for combined heat and power", December 2002

[7] Yongqiang Fu, San-Mou Jeng, "Confinement Effect on the Swirling Flow Generated by a Helical Axial Swirler"

[8] Yongqiang Fu, San-Mou Jeng, "Experimental Investigation of Swirling Air Flow in a Multipoint LDI Combutor", 8-11 july 2007

[9] Charles B. Graves, "Radial inlet swirler with twisted vanes for fuel injector", Oct 19, 1999

[10] Ying Huang, Vigor Yang, "Effect of swirl on combustion dynamics in a lean-premixed swirl-stabilized combustor", received January 2005

[11] David G.Lilley, "Annular Vane Swirler Performance", March-April 1999

[12] R. Thundil karuppa Raj, V. Ganesan, "Study on the effect of various parameters on flow development behind vane swirlers", September 2008

[13] P. Palies , D. Durox , T. Schuller & S. Candel, "Experimental Study on the Effect of Swirler Geometry and Swirl Number on Flame Describing Functions", Received 11 Aug 2010, Accepted 03 Nov 2010.