JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Thermal Analysis of Pulsejet Combustion using CFX

Bahadur Singh Mohne*, *Prakash Pandey ***
** Research scholar, Department of Mechanical Engineering, Vaishnavi Institute of Technology and Science Bhojpur Road, Risen.*
** Prakash Pandey, Department of Mechanical Engineering, Vaishnavi institute of technology and science Bhojpur Road, Risen.*

Abstract: Pulsejet engines are considered a feasible option for the propulsion of missiles and rockets owing to their advantageous characteristics of reduced weight and superior performance. The primary objective of this research is to use computational fluid dynamics (CFD) in order to evaluate the thermal properties and thrust generation of a pulsejet propulsion system. The ANSYS CFX software is used for conducting computational fluid dynamics (CFD) simulations of pulsejet engines. The analysis of the impact of multiple fuel inlets is conducted by a computational fluid dynamics (CFD) research, employing an eddy dissipation combustion model. The computational fluid dynamics (CFD) research demonstrates that an augmentation in fuel inlets results in a proportional elevation in outlet pressure and thrust force.

Key Words*: Pulsejet, Fuel Inlet, Combustion, CFD, Thrust.*

1. INTRODUCTION

The pulsejet engine has a notable degree of efficiency in generating thrust. The gadget demonstrates a significant thrust-to-weight ratio, making it a feasible option for incorporation into missile systems and unmanned aerial vehicles. When comparing pulsejet engines to ramjets, it can be seen that ramjets have comparatively reduced amounts of thrust. Ramjet engines have relatively poorer efficiency compared to other propulsion systems as a consequence of their diminished thrust capability. In scenarios where the turbojet engine is used only as auxiliary propulsion during takeoff and for a limited period, the implementation of pulse jet engines as start boosters presents significant advantages that surpass any possible disadvantages. Moreover, it is important to acknowledge that a singular combustor has the capacity to provide power to the engine via diverse modes including pulse, rocket, and ram [1].

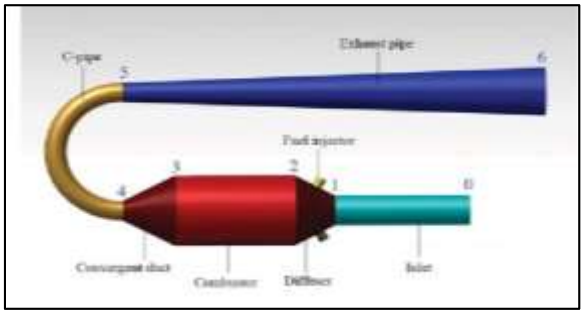

Figure 1: Schematic of pulsejet system [9]

The pulsejet engine is comprised of a combustion chamber and several electrical systems. The fuel injection system consists of two main components: the gasoline tank and the air compressor. The regulation of air and fuel intake into the combustion chamber is attributed to both the driver and computer systems.

2. LITERATURE REVIEW

O’Brien, John Grant [1] performed an evaluation of the performance characteristics and operating capabilities of the pulsejet engine. In addition, this paper presents the latest design possibilities aimed at improving thrust generation.

Christian Talbot McCalley [2] conducted an investigation on the propulsion mechanism of the UAV system. A study is undertaken to evaluate the feasibility of using gasoline and propane as alternative fuel options. Based on the study results, it has been noticed that propane fuel demonstrates a greater degree of propulsion when compared to gasoline fuel.

Michael Schoen [3] Experimental research on micro-scaled pulse jet engines, specifically focusing on the examination of the physical processes taking place inside the combustion chamber, have been done by the author. The study focuses on assessing the influence of pulsejet design on the generation of propulsive force. Based on the results obtained, it is advisable to run pulsejet engines using fuel that has a significant degree of reactivity.

Adam Kiker[4] An experimental research was undertaken on a microscaled pulsejet engine, with a recorded measurement of 8cm. The analysis is performed with hydrogen fuel. Based on empirical evidence, it has been found that a threefold increase in the chamber length of a pulsejet engine has promise for generating a 50% augmentation in thrust output.

Rob Ordon[5] The pulsejet engine, with a length of 50 cm, has undergone experimental scrutiny [5]. The investigation of pulsejet engine performance is carried out using a fuel blend including propane and ethanol. The analytical findings pertaining to the determination of the operating frequency shown a notable degree of agreement with the experimental results.

Daniel Paxson [6] conducted experimental study on the different dimensions of the pulsejet engine. The determination of the thrust force is conducted using a 50cm model in this study. The study primarily examines dimensional characteristics, including parameters such as the mean thrust force produced, exhaust diameter, and chamber dimensions.

U. Sreekanth, Subba Rao B [7] used computational approaches to examine the functionality of valve-less pulsejet engines. The evaluation of the thrust output of pulsejet engines involves the consideration of intake and exhaust lengths as factors.

Hussain Sadig Hussain [8] conducted a thermodynamic evaluation of a traditional pulsejet engine using experimental techniques. A comprehensive assessment is undertaken to examine the influence of various geometric factors on the thrust generation of a pulsejet engine. Geometric parameters that might be used as examples include the dimensions of the chamber and the specific fuel employed. The empirical evidence suggests that the operational efficiency of the engine is impacted by the size and arrangement of the combustion chamber.

3. OBJECTIVE

The primary objective of this research endeavor is to examine the thermal characteristics of a pulsejet engine and the mechanisms involved in generating propulsive force via the use of computational fluid dynamics techniques. The computational fluid dynamics (CFD) simulation of the pulsejet engine is performed using the ANSYS CFX software.

4. METHODOLOGY

The first step in the simulation of the combustion zone in the pulse jet engine involves creating a three-dimensional (3D) environment. The simulated combustion zone is then transferred into ANSYS design modeler for further study. The design that has been imported is subjected to a comprehensive examination in order to detect any surface imperfections, errors in the edges, or any other forms of faults. Figure 2 illustrates the configuration of the imported pulsejet combustion zone.

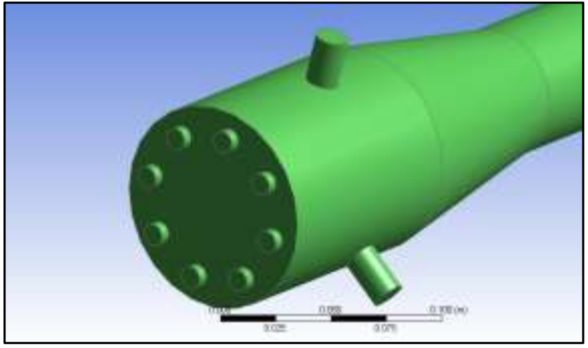

Figure 2: Imported CAD design of combustion zone

The combustion zone model has a mesh composed of tetrahedral elements. The meteorological conditions in the proximity of the fuel and air intake regions are conducive. The implementation of a tetrahedral mesh is necessary owing to its intricate characteristics and distinctive topological irregularities.

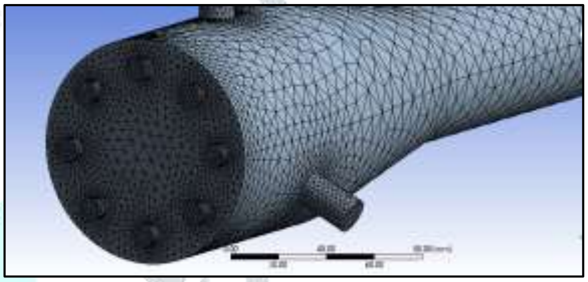

Figure 3: Meshed model of combustion zone

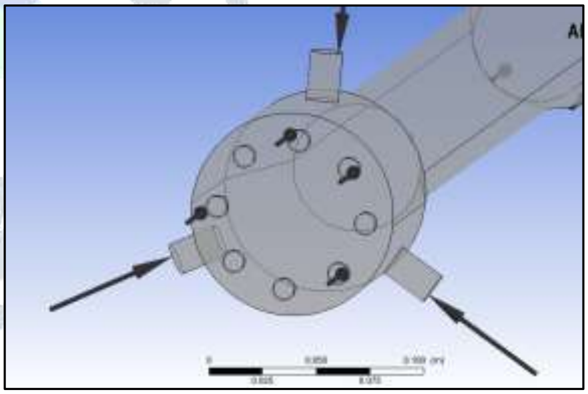

Figure 4: Boundary conditions

The area in which combustion occurs is typically denoted as the target zone. The combustion zone is defined as the region inside the reacting mixture when the pressure is equal to atmospheric pressure. The research utilizes a fluid model that integrates the thermal energy combustion model with eddy dissipation. The parameters at the entrance and exit of the combustion zone have been determined. The boundary conditions shown in Figure 5 pertain to the air intake. The determination of the air intake border is predicated upon the assessment of the mass fraction. The air intake should possess an oxygen mass proportion of 0.8. The term "jet" refers to a high-speed aircraft propelled by jet engines, which generate Hydrocarbon-derived fuel is used. The CFX library provides comprehensive documentation on characteristics such as molar mass, temperature limits, viscosity, and thermal conductivity. The material's parameters are shown in Figure 4.

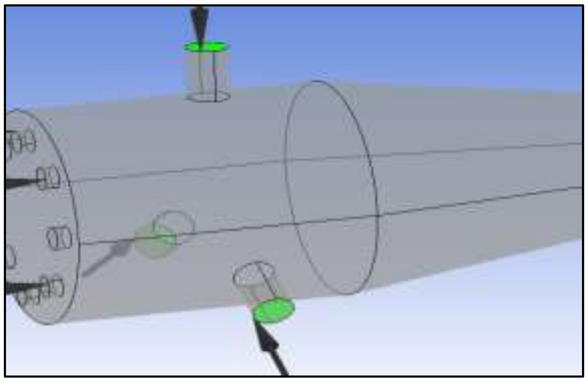

Figure 5: Jet fuel inlet

The diagram shown above illustrates the distribution of mass percentages in the intake of jet fuel. The prescribed volumetric proportion for jet fuel is 1. After the specification of the boundary condition, the simulation is started. The procedure involves the generation of a stiffness matrix and the calculation of root mean square (RMS) residual values for each iteration.

5. RESULTS AND DISCUSSION

In order to analyze the pressure distribution, velocity, and enthalpy of a pulsejet engine's complete combustion chamber design, a computational fluid dynamics (CFD) simulation is performed.

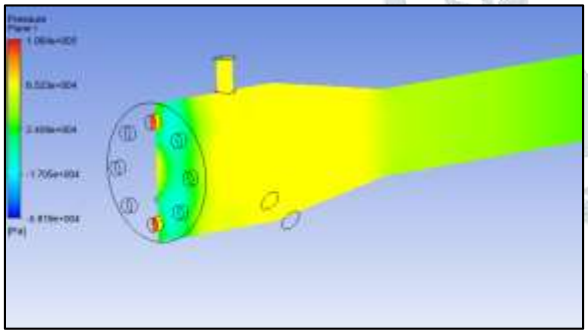

Figure 6: Pressure plot across plane

The pressure plot demonstrates a significant increase in pressure at the air intake, with a measured magnitude of 2409 Pa. The pressure inside the core, particularly in the combustion region, is quantified as 6523 Pascal (Pa). Figure 6 illustrates the velocity map, with a distinct emphasis on the region around the air entrance nozzle. The velocity has a magnitude of roughly 4.42 meters per second.

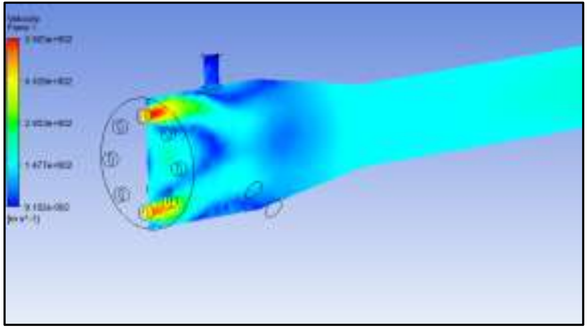

Figure 7: Velocity plot across plane

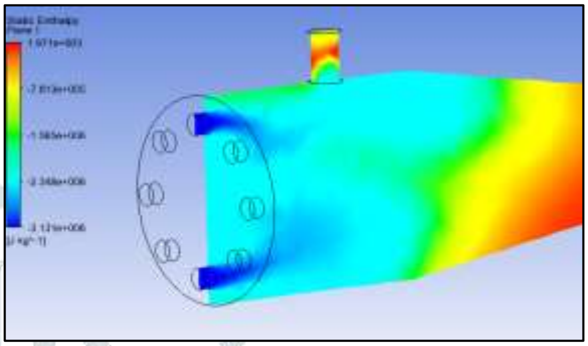

Figure 8: Static enthalpy plot across plane

Figure 8 illustrates the static enthalpy plot in the transverse plane. The exit nozzle of the pulsejet engine is where the maximum enthalpy is achieved, mostly due to the increased enthalpy resulting from burning.

6. CONCLUSION

The present study examines the combustion chamber of a pulsejet engine via the use of computational fluid dynamics (CFD) software. The examination of computational fluid dynamics (CFD) yields visual depictions of pressure, velocity, and static enthalpy distributions. By using a streamline diagram, it becomes feasible to make somewhat accurate predictions about the trajectories of fluids. The enhanced efficacy of the pulsejet engine's multiple intake design may be ascribed to the amplified enthalpy and combustion it generates. The observed rise in propulsion might perhaps be attributed to the concurrent elevation in enthalpy.

REFERENCES

1. O'Brien, John Grant (1974) "The pulsejet engine: a review of its development potential".

2. Christian Talbot McCalley (2006) "Experimental Investigation of Liquid Fueled Pulsejet Engines".

3. Schoen MA (2005) "Experimental investigations in 15 cm class pulsejet engines, M.S. Thesis, Department of Mechanical and Aerospace Engineering", NC State University, Raleigh, NC, 27695.

4. Kiker AP, Thesis MS (2005) "Experimental investigations on mini pulsejet engines" Department of Mechanical and Aerospace Engineering., NC State University, Rayleigh, NC, 27695.

5. R.L. Ordon, Thesis MS (2006) “Experimental investigations into the operational parameters of a 50 cm class pulsejet engine” Department of Mechanical and Aerospace Engineering, NC State University, Raleigh, NC, 27695.

6. Paxson DE, Litke PJ, Royce P Bradley, John L Hoke (2006) “Performance Assessment of a Large-Scale Pulsejet-Driven Ejector System,” AIAA paper 2006-1021.

7. U. Sreekanth, Subba Rao B, Nagaraju A (2017) “performance and analysis on valve less pulse jet engine” Vol-3, issue 1.

8. Hussain sadig Hussain (2008) “Theoretical and Experimental Evaluation of Pulse Jet Engine” A thesis submitted in partial fulfillment of the requirements for the degree of M. Sc.in Energy Engineering.

9. Modi, S.K., Khinchi, S.M., Rajpurohit, N., Rami, A., & D, S. (2021). Design and Development of Valveless Pulsejet Engine. *2020 3rd International Conference on Energy, Power and Environment: Towards Clean Energy Technologies*, 1-6.