COMPUTATIONAL FLUID DYNAMIC ANALYSIS OF A PULSE JET ENGINE

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Abstract - *The quality of combustion in the combustion chamber has a significant impact on the thrust force generated by the pulsejet engine, which is dependent on the number of fuel inlets. This study employs the CFD technique to investigate the pulsejet engine, specifically the thrust generated by the eddy dissipation combustion model and the finite rate chemistry combustion model. The comparative study is based on the generation of enthalpy, pressure, and thrust force. The CAD model of the pulse jet engine is created with Creo design software, and the CFD analysis is performed with ANSYS CFX software. The static enthalpy, pressure, and thrust force of three different pulse jet designs are calculated using both eddy dissipation and finite rate chemistry combustion models.*

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

1. INTRODUCTION

A pulsejet engine is a jet engine that uses the heat of a fire. The pulsejet engine can be built statically with a few missing components. Pulsejet engines are lightweight jet engines with a negative congestion rate, which results in some low pressure. Another noteworthy line of research for pulsejet engines is the pulse engine, which involves repeated engine shutters and can provide high pressure and efficiency. One of the most basic forms of propulsion known to man is the pulsejet. They are well-known for having few to no moving parts, scalability, low cost, ease of use, and extremely high noise levels.

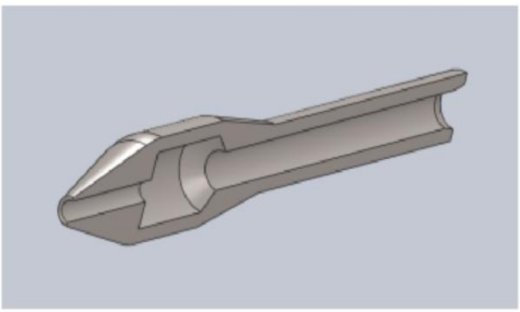

Figure 1: Simple valve less pulsejet in half section view

Ray Lockwood of Hiller Aircraft Corporation improved on the valve less jet in the 1960s by developing a "U-shaped" pulsejet with the inlet and exhaust tubes facing the same direction. As shown in Figure 1.2, this allows all thrust to be directed in the same direction, maximizing thrust. This U-shape has the obvious advantage of increasing thrust, but it also has several disadvantages. The largest advantage is that they have nearly twice the cross-sectional area of a traditional straight pulsejet. This combined with the fact that drag increases as the square of velocity, results in a significant drag penalty at higher forward flight speeds. Nonetheless, this U-shaped design is still popular among hobbyists who tinker with electronics pulse jet.

1.2 Jet Theory and Design

For nearly a century, the pulsejet's operation has been fairly well understood. Because the jet has few moving parts, its acoustic properties are almost completely described throughout the jet. Over the last decade, NC State has conducted extensive computational and experimental research, and this paper builds on that work. Any pulsejet's main design consists of three main sections, as shown in Figure 1.4. On each cycle, the inlet is a round tube that serves as the primary method of introducing fresh air into the system. It has the smallest cross-sectional area because it is the shortest section of the pulsejet.

2. Objectives

The goal of this research is to use CFD to investigate pulsejet engines by increasing the number of fuel inlet nozzles and diffuser angle. The specifics are as follows:

1> CAD design of a pulsejet engine using Creo 2.0 software

2> CFD analysis with ANSYS CFX software based on the base design

3> For base design, determining thrust generated, pressure plot, and velocity plot

4> Computer-aided design (CAD) modelling of new designs with multiple fuel inlets

5> CFD analysis with ANSYS CFX software on a new design with multiple fuel inlets

6> Creating a thrust plot, a pressure plot, and a velocity plot for a new design with multiple fuel inlets.

2.1 CAD modelling

The computational domain is modelled using Creo 2.0 which is sketch based, feature based parametric 3d modelling software developed by PTC. The CAD model is prepared using extrude, pattern, blend and revolve tools. The details of steps involved are discussed in next section.

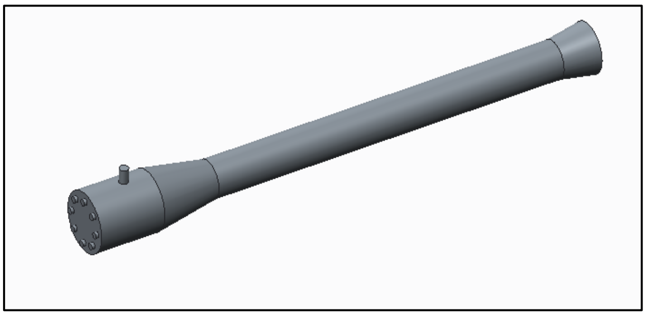

Figure 2.1: CAD model of pulsejet engine with single inlet

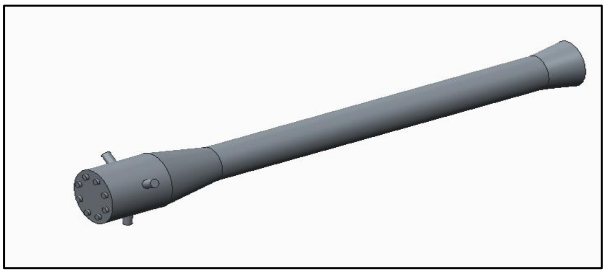

Figure 2.2: CAD model of pulsejet engine with 3 fuel inlet

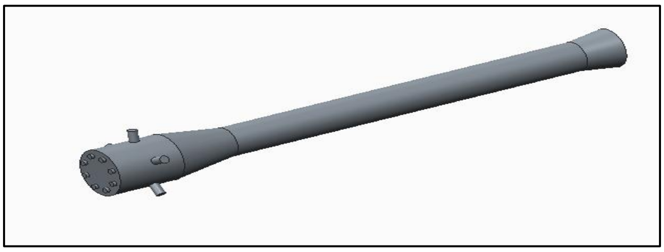

Figure 2.3: CAD model of pulsejet engine with 5 fuel inle

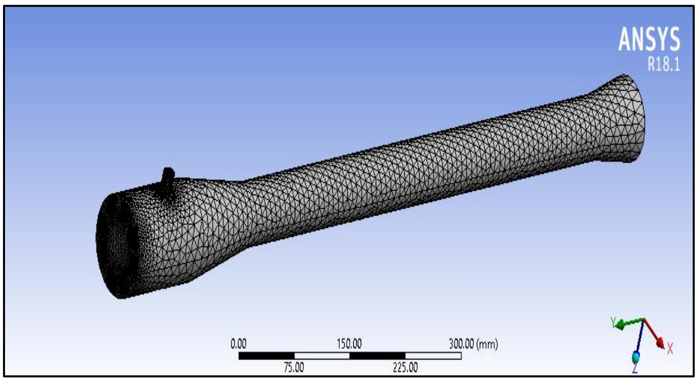

Figure 2.4 Meshing of single fuel inlet cooler

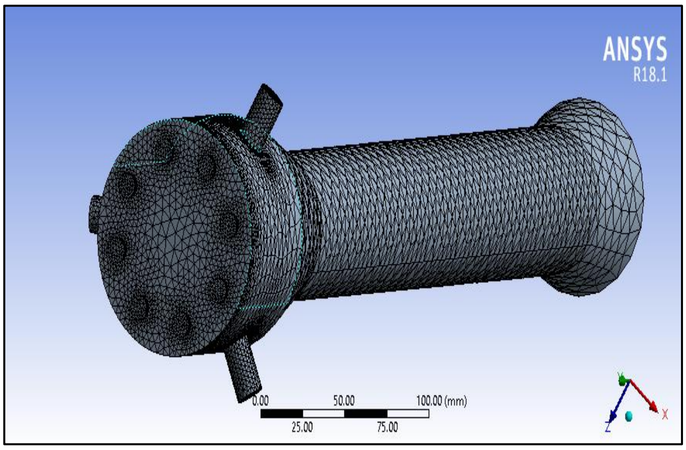

Figure 6.13 Meshed model of 3 fuel inlet

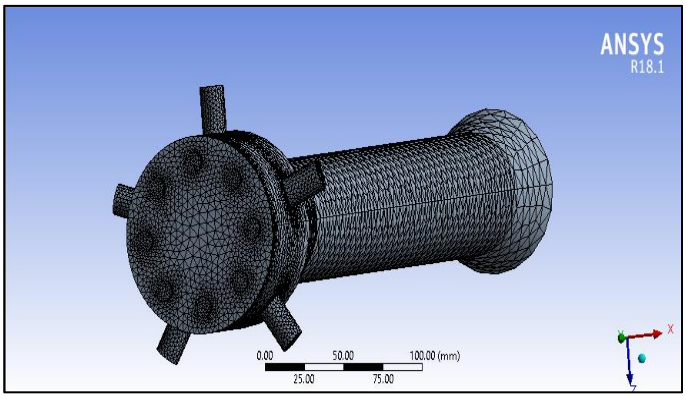

Figure 6.14Five fuel inlet design

1 Single Fuel Inlet Configuration

The CFD analysis is conducted on single fuel inlet design of pulsejet engine and the results are shown in figure 7.1 below. The fluid flow characteristics are generated and pressure plot along with enthalpies are generated.

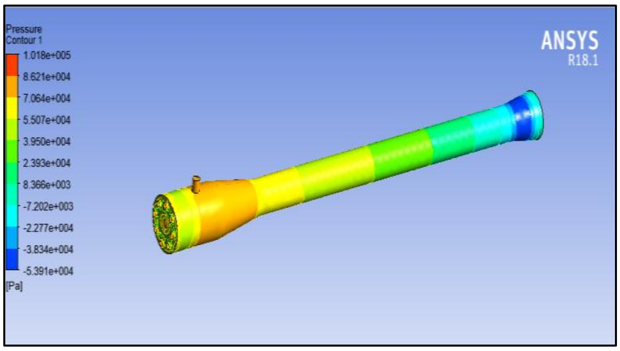

Figure 7.1: Single fuel inlet pressure plot

The air velocity is higher at the inlet with nearly 614m/s and the velocity reduces along the length of pulsejet engine and pressure near the exit is nearly 460.7 m/s. The velocity plot is shown in figure 7.2 above.

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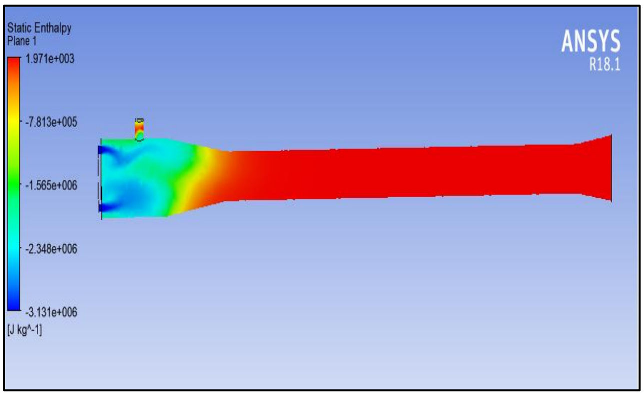

Figure 7.3: Enthalpy plot of single fuel inlet

The enthalpy is maximum on most of the regions as shown in figure 7.3 above with magnitude of nearly 1971 J/kg K.

2.2Three Fuel Inlet Configuration

The CFD analysis is conducted on single fuel inlet design of pulsejet engine and the results are shown in figure 7.4 below. The fluid flow characteristics are generated and pressure plot along with enthalpies are generated.

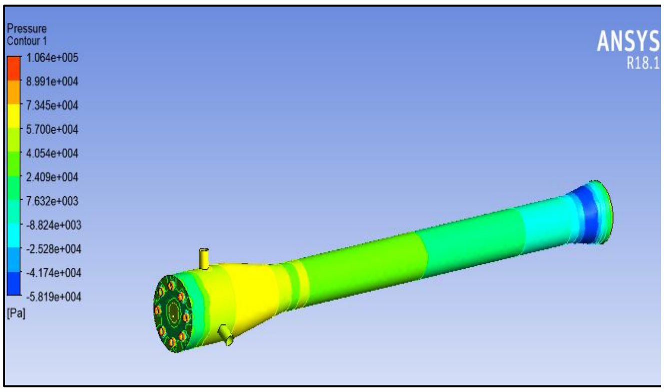

Figure 7.4: Three fuel inlet pressure plot

3. RESULTS AND DISCUSSION

Table 3.1: Thrust data and Pressure data

Design Configuration	Pressure (Pa)	Thrust (N)
1 Fuel Inlet	1788.23	8.87
3 Fuel Inlet	4737.16	23.51
5 fuel Inlet	4787.16	23.76

The pressure generated at outlet and corresponding thrust force is shown by table 3.1 above. The thrust force generated is minimum for single fuel inlet i.e. 8.87N and increases multifold with increase in number of fuel inlet. The three-fuel inlet and five fuel inlet design configurations have shown very high thrust force. The static enthalpy table is shown in figure 7.10 below shows similar trend.

Table 3.2: Thrust and Pressure using Finite Rate Chemistry Model

Design Configuration	Pressure (Pa)	Thrust (N)
Single Fuel Inlet	1789.15	8.879
Three Fuel Inlet	4737.52	23.49
Five fuel Inlet	4790.58	23.76

Table 3.2 compares the thrust and pressure values of various design configurations. The thrust force generated is 8.87N for a single fuel inlet and multiplies as the number of fuel inlets increases. The three-fuel inlet configuration has a thrust force of 23.49N, and the five-fuel inlet configuration has a thrust force of 23.76N.

4. CONCLUSION AND FUTURE APPLICATIONS

Final Thoughts Proper combustion model selection is critical for accurate prediction of gas flow behaviour, thrust generation, and enthalpy generation. The number of fuel inlets has had a significant impact on the combustion characteristics, which have influenced the thrust and pressure developed at the pulse jet engine's exit. The enthalpy was underestimated in the finite rate chemistry combustion model because the model did not account for the effect of turbulent fluctuations, whereas the reaction rate in the eddy dissipation combustion model is determined by turbulence.

1> Using the k-epsilon turbulence model, fluid flow predictions inside the pulsejet chamber are reasonably accurate.

2> The type of combustion model has a significant impact on the results of CFD analysis.

3> Regardless of the combustion model used, the multifuel inlet of a pulsejet engine exhibits a higher combustion rate and outlet pressure.

4> the thrust generated by the multi fuel inlet design of the pulsejet engine is greater than the thrust generated by the single fuel inlet design.

5> the pressure profile is the same for all pulsejet engine design configurations. The maximum pressure is obtained in the combustion chamber, and it gradually decreases as the engine exits.

6> When compared to the eddy dissipation combustion model, the finite rate chemistry predicted a 20KJ/K higher enthalpy for the five fuel inlet design.

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. Liu Min, Yu Ling, Cai Wen-xiang (2016) "Experiment Analysis of Combustion Performance in Pulse Jet Engine" 3rd International Conference on Power and Energy Systems Engineering, CPESE 2016, Kitakyushu, Japan 8-10.

10. Sainath K, RuhailMasood, MohdSalahuddin, Md Ismail, MohdKhaleelUllah et al., (2014) "An Investigation Report & Design of PULSE JET ENGINE", IJMEIT// //ISSN-2348-196x 2: 859-866.