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Design and Analysis of Improved Pulse Jet Engine

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Abstract: The project entitled design and analysis of improved pulsejet engine is based on advance propulsion technique. The main objective of this project is to design a pulsejet engine which is able to produce high thrust and improved specific fuel consumption for the same amount of fuel used. This can be done by providing continuous combustion in the combustion chamber with the help of flame holders and also reducing the velocity of the inlet air by providing a divergent type diffuser. Initially pulsejet engines were designed as a target drone and recently pulse jet engines find their application in passenger and military aircrafts but the main drawback preventing the pulse jet engine from using in passenger aircraft is its low fuel efficiency. The flame holder provided inside the combustion chamber stabilizes the flame thus initiating continuous combustion inside the combustion chamber. The flame holder used is a baffle type flame holder because it is simple and efficient. The pulse jet body will be designed using the CATIA V5 R20 software and the meshing will be done using GAMBIT and the analysis will be done using ANSYS Fluent 12 CFD package.

Keywords: Propulsion, Pulse Jet Engine. Combustion, Combustion Chamber, Flame Holder, Fuel Efficiency, Thrust.

I. INTRODUCTION

Pulsejet Engine is type of Air Breathing Engine. It is very similar to Ramjet Engine in construction expect that in addition to the diffuser at intake, combustion chamber and exhaust nozzle, it has mechanically operated flapper valve grids which can allow or stop air flow in the combustion chamber. Thus Pulsejet is an intermittent flow, compressor less type of device with minimum number of moving parts. Pulse jet engine is a type of jet engine in which combustion occurs in pulses. Pulsejet engines can be made with few or no moving parts, and are capable of running statically. Pulse jet engines are a lightweight form of jet propulsion, but usually have a poor compression ratio, and hence give a low specific impulse. One notable line of research of pulsejet engines includes the pulse detonation engine which involves repeated detonations in the engine, and which can potentially give high compression and good efficiency. Pulsejet Engines are characterized by simplicity, low costt of construction, and high noise levels. Pulsejet fuel efficiency is a topic for hot debate, as efficiency is a relative term. While the Thrust-to-Weight ratio is excellent, Thrust Specific Fuel Consumption is generally very poor.

The Pulsejet uses the Lenoir cycle which lacking an external compressive driver such as a Otto cycle's piston, or the Brayton cycle compression turbine, drives compression with acoustic resonance in a tube. This limits the maximum (pre-combustion) pressure ratio to perhaps 1.2 to 1. Pulsejets can run on almost anything that burns, including particulate fuels such as Sawdust or Coal powered. Pulsejets have also been used in both control-line and ratio controlled model aircraft. Usually pulsejet engine is of two types, valved and valveless engines. The valved type consists of single moving part "valve" which controls the flow of fresh air into the combustion chamber, the valveless engine is hollow type with "Zero" moving parts .Recently a research is going on PDE (Pulse Detonation Engine) in NASA which is believed to be more efficient when compared to conventional turbojet engines. Generally valveless pulsejet engine consumes high fuel, the thrust of the engine is less and it is not self started. They have been used in model aircraft, target drones, go-kart and cruise missiles.

II.DESIGN OF PULSE JET ENGINE

The pulse jet body will be designed using the CATIA V5 R20 software and the meshing will be done using GAMBIT and the analysis will be done using ANSYS Fluent 12 CFD package as shown in Fig.1.

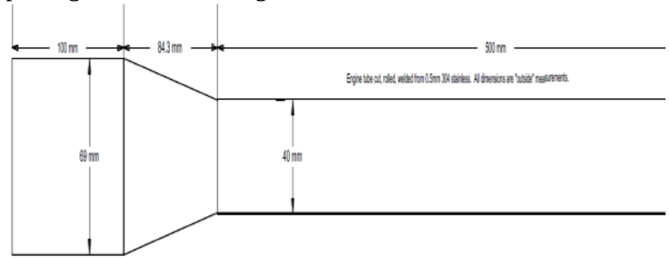

Fig.1. Dimensions of Pulse Jet Engine.

The flame holder will be designed using CATIA v5 R20 software and it meshed to the pulse jet engine and pulse jet engine is analysed with flame holder in an ANSYS FLUENT

CFD package. The dimensions of the flame holder is shown in 3-D Fig.2.

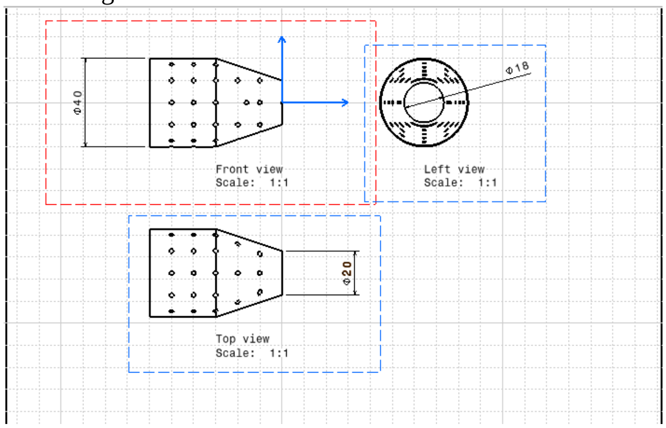

Fig.2. 3-D View of Flame Holder Design with Dimensions.

And the design of intake venture diffuser is drawn using CATIA software and it will be analysed using CFD software as shown in Fig.3.

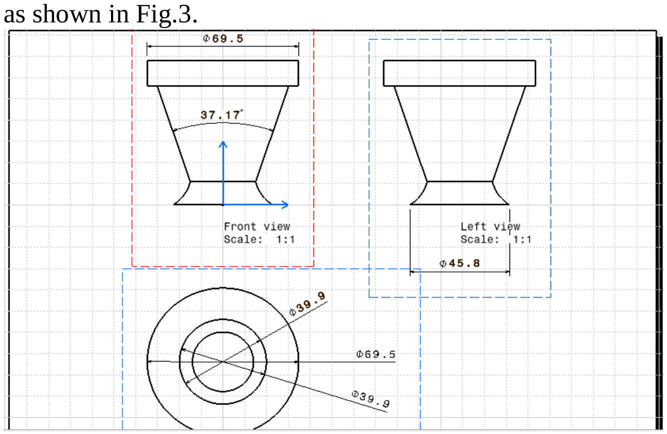

Fig.3. 3-D View of Intake Venture Design with Dimensions.

The dimension of the pulse jet engine is similar to that of the one analysed by. The model with above dimensions is created in CATIA V5 R20 and this model will be imported to gambit where it will be meshed as shown in Fig.4. After meshing and creating the boundary conditions the model will be read using ANSYS FLUENT12. Here the model is analysed using pressure based solver as the project involves pressure, velocity, amount of fuel and air injected as shown in Fig.5.

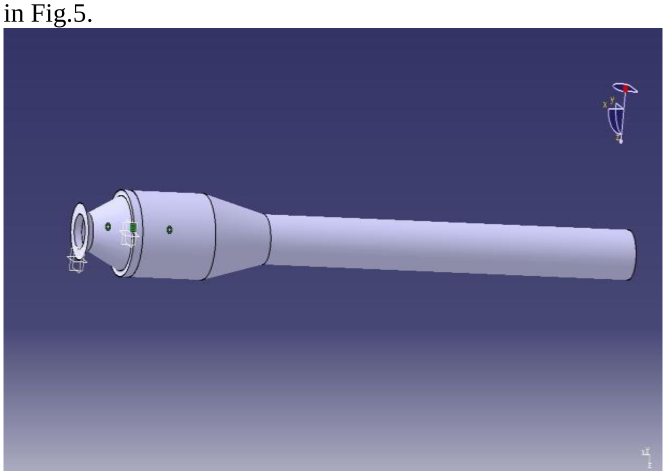

Fig.4. Pulse Jet Engine with Intake Venturi.

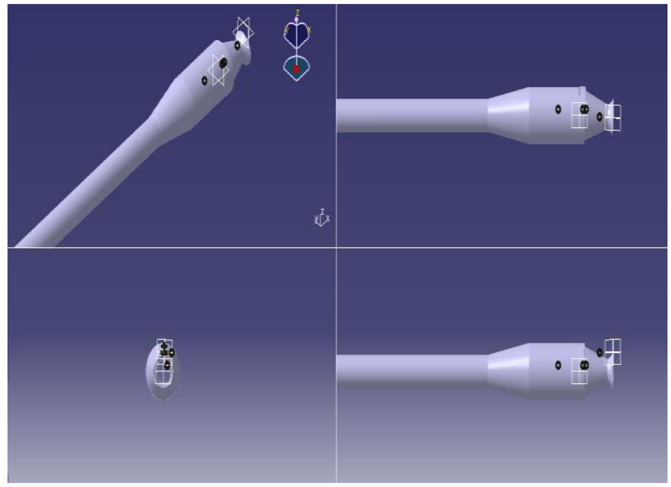

Fig.5. 3-D View of Pulse Jet Engine Design.

III. ANALYSIS OF PULSE JET ENGINE

The meshing process carried out through the body of the designed pulse jet engine as shown in Fig.6. The number of nodes are 45352, the type of cell used is tetrahedral, and the total number of cells are 230750.

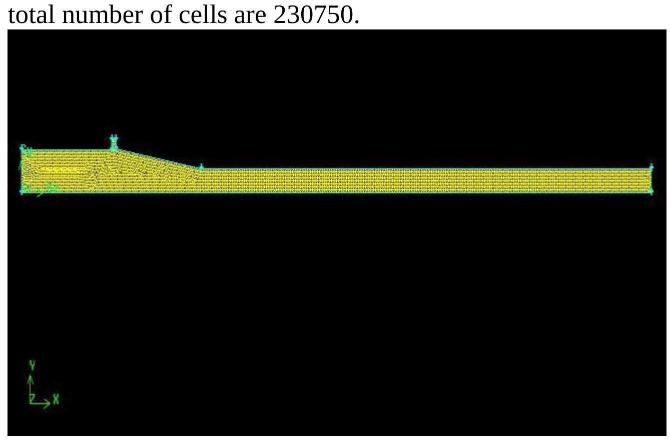

Fig.6. Picture of Meshing.

The analysis process is done by the ANSYS FLUENT 12 and get the results of velocity, temperature, pressure, turbulence and mass fraction contour through the body of the pulse jet engine as shown in Figs.7 to 10.

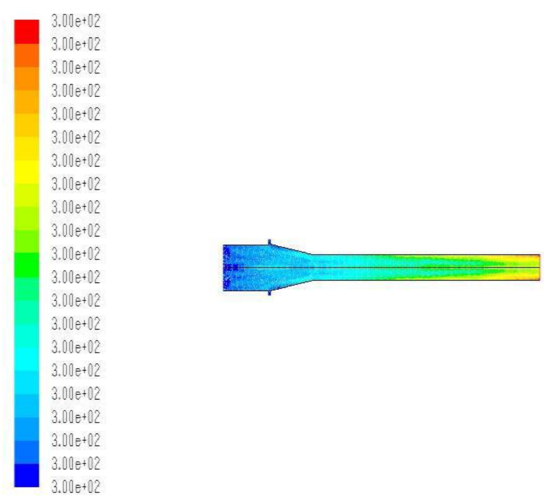

Fig.7. Temperature Contour.

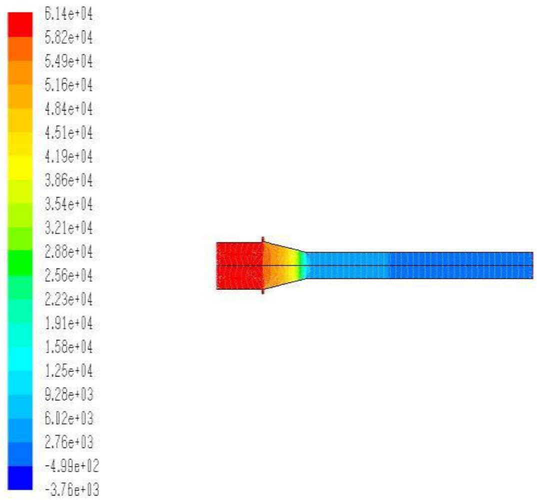

Fig.8. Pressure Contour.

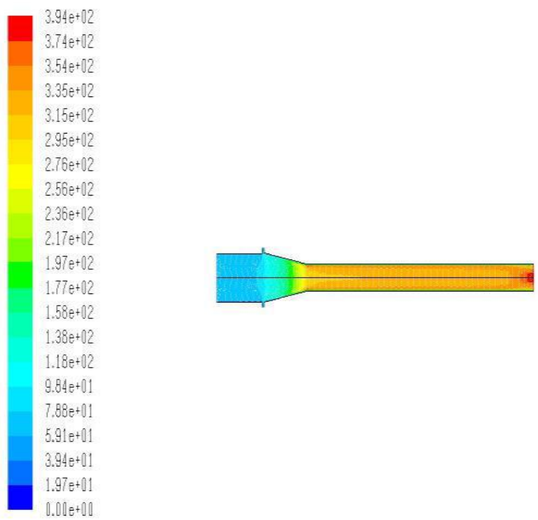

Fig.9. Velocity Contour.

The Fig.9 shows the velocity through the dimensions of the body.

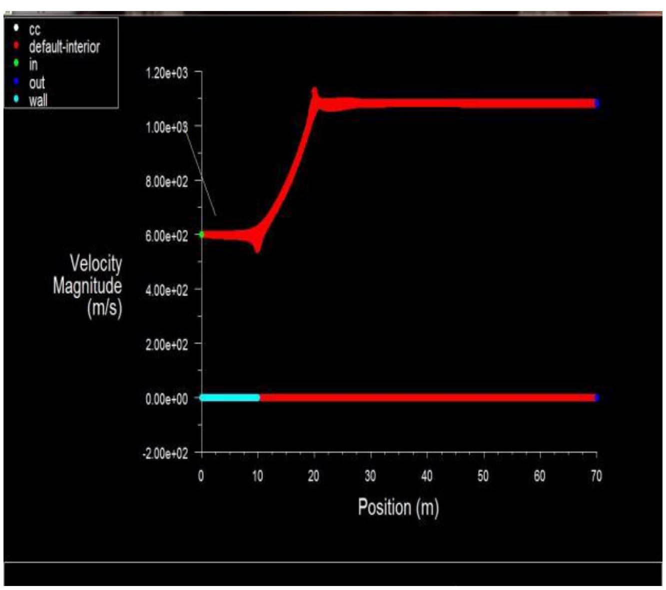

Fig.10. Velocity Graph.

IV. RESULT

After analysis, the below results are obtained.

TABLE I: Analysis Results

01	INLET VELOCITY OF THE FUEL	82m/s
02	INLET VELOCITY OF THE AIR	72m/s
03	FUEL USED	METHANE AND AIR
04	EXIT VELOCITY	$3.15*10^2$m/s
05	INLET STATIC TEMPERATURE	$3.00*10^2$K
06	EXIT STATIC TEMPERATURE	$3*10^2$K
07	INLET PRESSURE	$6.14*10^4$Pa
08	EXIT PRESSURE	$2.76*10^3$Pa
09	TOTAL NUMBER OF ITERATION	8000
10	NUMBER OF NODES	45352
11	TYPE OF CELL USED	TETRAHED RAL
12	NUMBER OF CELLS	230750
13	PERCENTAGE OF TURBULENCE	$9.45*10^2$%
14	MASS FRACTION OF O_2	$2.3*10^{-1}$
15	MASSS FRACTION OF CH_4	$8*10^{-1}$

V. DISCUSSION AND COMPARISION

The fuel is injected to the inlet at 82m/s, the air is injected to the inlet at 72m/s, the fuel used is methane and air. The velocity of air and fuel at exit is 3.15*102m/s respectively and the static temperature at exit is 3*102k, whereas pressure at inlet and the exit are 6.14*104pa and 2.76*103pa respectively. After analysing the pulsejet engine with flame holder the result obtain from the engine and thrust required will be high when we comparing with a pj8 pulse jet engine.

VI. CONCLUSION

From the above analysis it is understood that the fuel efficiency can be improved by adding flame holders in the combustion chamber, initially pulsejet engines were designed as a target drone and recently pulse jet engines find their application in passenger and military aircrafts but the main drawback preventing the pulse jet engine from using in passenger aircraft is its low fuel efficiency, the flame holder provided inside the combustion chamber stabilizes the flame thus initiating continuous combustion inside the combustion chamber. The flame holder used is a baffle type flame holder because it is simple and efficient.

VII. REFERENCES

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