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Department of Mechanical Engineering and Applied Science, Sri Krishna Institute of Technology, Bangalore, India

Valueless Pulse Jet Engine

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ABSTRACT: Basic and methodical structure of pulse jet engine is efficient for aeronautical fleeting operation. A dynamic control system expands the operating range and reduces the fuel consumption considerably. The pulsejet is the only jet engine combustor that shows a net pressure gain between the intake and the exhaust. In its most basic form – the valve less pulsejet -- the jet engine can be just an empty metal tube shaped in a proper way.

We chose the Lockwood's design of pulsejet engine. By using the computational fluid dynamic, we have analyzed and modified the design of pulsejet engine. This project provides an overview of this unique process and the results of these design modifications are reported.

KEYWORDS: Pulse jet engine, exhaust, Lockwood design, valve less type.

I. INTRODUCTION

A pulsejet is a simple form of an air breathing jet engine that has few or no moving parts. The pulsejet acts in cycles, or pulses, where air is drawn into a combustion chamber, mixed with fuel, ignited, and then accelerated out of a nozzle providing thrust. There are two basic categories of a pulsejet engine. The first is a valved design, in which the combustion process is controlled by valves. The air passes through these valves, and then when combustion begins, the valves slam shut, forcing the combustion products to exit through the nozzle, providing forward thrust. This type of engine requires more parts for the valved system, which results in potential for more problems.

The second category of pulsejets is known as a valve less system, in which the valved system is completely removed. This results in the valve less designs having no moving parts, resulting in an engine that is easier to construct and maintain. Valve less pulsejets have three basic parts: the intake tubes, combustion chamber, and exhaust nozzle. When combustion occurs, the intake tubes attempt to limit the expulsion of combustion products, but do not stop it all together, as in the valved design. This means that while the majority of the combustion products exit the nozzle, a small part will exit from the intake. Because of this, many valve less designs have the intake facing in the same direction as the nozzle, to provide all thrust in the same direction.

1.1 Propulsion

The act of moving something forward is called propulsion. A technological system uses an engine or motor as the power source, wheels and axles, propellers, or a propulsive nozzle to generate the force. Components such as clutches or gearboxes may be needed to connect the motor to axles, wheels, or propellers. Biological propulsion systems use an animal's muscles as the power source and limbs such as wings, fins or legs as a propulsor.

Vehicular Propulsion:-

A vehicle is defined as a thing which is used to transport people or goods called payload from one place to another. The types of vehicular propulsion are as follows:-

Ground vehicle propulsion: -Ground propulsion is any mechanism for propelling solid bodies along the ground. The propulsion system often consists of a combination of an engine or motor, a gearbox and wheel and axles in standard applications that use the traction or the friction force between the wheel and the ground. Reaction engines are also seen used in ground propulsion in extreme cases.

Aerial vehicle propulsion system:- Aerial propulsion system is a mechanism or act of propelling an aircraft that is flying countering the gravity. The aircraft propulsion system contains an engine or a motor that produces thrust by the discharge of high velocity gases and works on the principle of Newton's third law of motion hence they are called reaction engines.the aircraft engines must perform two functions that is to produce enough thrust to counter act the



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force of gravity with the help of the aerofoil shaped wing that generates lift with the fast moving air over them .and the second thing is to generate thrust to counter the drag that the aircraft generates. The drag is directly proportional to the speed of the aircraft. The thrust is produced by the engine which can be either a jet engine or a propeller engine.

Space propulsion system: A space propulsion system means to propel a space craft out of the atmosphere and in the vacuum it works very similar to the air propulsion system. But uses only reaction engines that forces or blows a fast flowing jet of hot gases to produce thrust. It uses solid and liquid propellants mostly.

Pulse jet engine

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The pulsejet is a compressor less, unsteady flow jet engine without wave pre-compression of the combustible charge. A pulse jet engine is a type of reaction engine in which combustion takes place in pulses A valve less pulsejet is mechanically very simple and consists of a short inlet tube leading to the combustion chamber, followed by a combustion chamber and a 'u' shaped tube leading to an exhaust, as shown in Figure 1.6. A fuel injection system is located in the combustion chamber. The air flowing into the engine through the intake is mixed with a fuel spray, and the mixture is ignited. As a result of the pressure rise generated by the explosion, the exhaust gases expand outside through the exhaust and intake tube. The exhaust of the burned gases generates expansion waves that reduce the pressure in the combustion chamber and a fresh charge of air enters through the intake while the exhaust carries back a part of the exhaust flame and ignites the charge in the combustion chamber. The cycle is then repeated. A spark is required only to start because after the first cycle, the hot gases from the previous cycle ignite the fresh combustible charge. The most common version of the pulsejet is a valve less pulsejet; however, there exist valved pulsejets too. both the ends of the valve less pulse jet engine is facing the same direction as the thrust comes out of both intake and exhaust.



Fig 1.1shows a valve less pulse jet engine

II. LITERATURE SURVEY

Bruce Simpson: - problems in a pulse jet design, if the pipe is too short. If the pipe is too short then the engine won't run because all of the hot gases will leave the tailpipe. This means there's nothing left to ignite the new air-fuel mixture drawn in during the intake phase. If the pipe is too long then the exhaust gases will "burn out" and cool down too much making it impossible for them to ignite the fresh air/fuel mixture. It is worth noting that most engines are far more tolerant of a too-long pipe than a too-short one. So in designing an engine it always better making the pipe a little longer. If the intake area too big if the diameter in the front of the engine is too big then the vacuum necessary to suck some of the hot exhausts gases back to compress and ignite the fresh air/fuel charge will dissipate too quickly and the engine will not run. If the intake area is too small If the diameter is too small then not enough air/fuel mixture will be drawn into the engine to provide adequate combustion and the engine will either not run or will run with less than optimal levels of power.

Divyesh B. Patel, Jayesh R. Parekh A pulse jet engine (or pulsejet) 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. Pulsejet engines are characterized by simplicity, low cost of construction but high vibrations and 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.

K Sainath A pulse jet engine is a reaction engine in which combustion occurs in pulses .pulse jet engine can be made with few or no moving parts and are capable of running statically. they are light weight form of jet propulsion engines but usually have a small value compression ratio and hens give a low specific impulse one notable line of research of



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pulsejet engines includes the pulse detonation engine [PDE] which involves repeated detonations in the engine and which can potentially give high compression ratio and good efficiency [η]

III. METHODOLOGY

The work flow of this project work is as follows,

1. Design and Drafting

The Lockwood design was implemented due to the simplicity in design, construction and ease in manufacturing The Lockwood design was invented tested and patented in the United States back in the 1960's. The tested design was of a smaller version and generated less thrust. Based on our literature survey the output thrust multiplication of a valve less pulse jet engine can be done proportional to the dimensions of the respective designs. The basic design is implemented and scaled up to a ratio of 1.5 based on the objective of this project to produce a greater output thrust.CAD designing is done using the catia V5R20 and manual drafting methods.

2. Selection of Material.

Based on the theoretical calculations and studies on the literature both showed that the walls of the engine reach working temperature above 800 to 1000 degree Celsius. In order to withstand the high working temperature, thermal stresses, and hot strength taken into account wide range of steel and their properties were studied. According to the choices the most economical, reliable and suitable material that serves the purpose is the stainless steel 304grade. The founders of this design built and tested their prototype with a wide range of materials ranging from mild steel to stainless steel of different grades according to the results by which they found the stainless steel of 304 310 315 were better in performance temperature distribution and thermal conductivity.

3. Mapping and Cutting

The unfolded sections are mapped on to the stainless steel sheet measuring 2400*1200*2 mm which is to be cut individually in order to be rolled into to individual components. Standard practice of cutting or parting the stainless steel sheet is through punching blanking or recent non-conventional machining process such as laser machining or electron beam machining. Due to economic, material wastage, transport and handling constraints conventional method of using abrasive and silicon disks is used to cut the stainless steel sheets.

4. Rolling and Welding

4.1 Roll forming

The type of cold rolling process where in the rolling of the sheet is done way below the re-crystallization temperature of the metal. The rollers induce elastic and plastic deformation on the sheet metal and form them into cylindrical shells of required radius by altering the clearance distance between the rollers.

4.2 Welding Process.TIG welding is opted to obtain a seam less Weld on the stainless surface as arc welding cannot be done for stainless steels. Since the operating temperature of the engine is around 900deg Celsius arc welding will not sustain and becomes porous at elevated temperatures.

5. Assembly and Clamping

The fabricated model is assembled with the gas lines and is clamped to a rigid yet light weight frame to obtain strong support less overall weight and to withstand the vibrations caused in the engine, through which we can obtain accurate results without losses.

6.Testing with all the components in place testing of the pulse jet engines is the next step on the line to make sure everything is working up to expected standards and to ensure there is no faults in the operating procedures implemented. **7. Results and Discussions** results obtained are thus tabulated and compared with the theoretical outputs and standards implemented for the design, as per the objective of the project and to see that with frequent trials expected output is obtained.

IV. THEORETICAL ANALYSIS OF PULSE JET

Theoretical models allow experiments to be conducted without the need for physically building a test rig, thus reducing cost and development time. Pulse jets have an intricate pulsating combustion system, making them very difficult to model. Computer simulations allow the flow to be analysed and engine dimensions varied to optimize performance. Understanding the complexity of the pulsejet cycle was the major hurdle in developing a computer model. Simple iterative technique handled fluid properties such as pressure, temperature and velocity; however, were



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unable to handle compression or rarefaction waves. The model accounted for gradual area changes, wall friction, heat transfer, entropy gradient sand boundary conditions.

Construction of Model

The detailed step by step procedures and events that have been followed in order to fabricate the working model of the valveless pulse jet engine according to the aim of the project are as follows

Design and 2D Drafting: The Lockwood design was implemented due to the simplicity in design. The basic design is implemented and scaled up to a ratio of 1.5 based on the objective of this project to produce a greater output thrust. **Computer Aided Design**: CATIA enables the creation of 3D parts from 2D sketches, sheet metal, composites, moulded, forged and tooling parts. The software provides advanced technologies for mechanical surfacing. 3D modelling based on the 2d draft a 3d model was created using the generative shape design options on the Catia.



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Fig 1

Fig 2

The whole component is then divided into 10 individual components for fabrication purposes. Technically called the unfolded drawings of all the cylindrical components and conical frustums are given below using mathematical formulae as listed below

Selection of Material: Based on the theoretical calculations and studies on the literature both showed that the walls of the engine reach working temperature above 800 to 1000 degree Celsius. Materials were tabulated and the most economical of the variants was selected (Stainless alloy). The following figure shows the graph of temperature VS yield strength of SS304 and other variants.



Considering all the factors stainless steel of grade 304 is chosen to be the optimum and economic choice of all.



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Rolling and TIG Welding Process: A Roll bender is a mechanical jig having three rollers used toform sheet metal into a cylindrical shell. The rollers freely rotate about three parallel axes, which are arranged with uniform horizontal spacing. Two outer rollers, usually immobile, cradle the bottom of the material while the inner roller, whose position is adjustable, presses on the topside of the material.



TIG welding is opted to obtain a seam less Weld on the stainless surface as arc welding cannot be done for stainless steels. Since the operating temperature of the engine is around 900deg Celsius arc welding will not sustain and becomes porous at elevated temperatures. All the individually rolled components are now welded to each other according to the design.







APPLICATIONS:

The simplicity of design and construction of these pulse jets make them a better choice for aviation and marine propulsions and racing propulsion system.

- Since thrust multiplication depends on the size of the engines, the engines can be manufactured in a wide range of sizes with respect to the required thrust output used to propel a wide range of payloads.
- Since increasing thrust or throttling is done by altering the mass of fuel supplied to the engine only with no other mechanisms and fuel supply systems these engines finds extensive usage in target drones and unmanned Aerial vehicles (UAV).
- The cost of manufacturing and capability of starting from station makes it a choice of missiles and weapons of mass destruction.
- Since there are no internals parts need of lubrication and maintenance are eliminated and makes it a choice for marine and amphibious propulsion systems.
- Since the fuel energy is directly converted into heat energy it can be efficiently used as space heaters. •



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V. CONCLUSION

This project showed that the valve less pulse jet engines are the simplest form of jet engines and are very simple in terms of design to manufacture and can be run on zero maintenance, since the design does not contain any moving parts this gives a leading edge in time taken to manufacture a pulse jet engine. This design also eliminates the need of a compressor and a turbine as in a turbojet engine thereby reducing the size including auxiliaries and complexities. The Lockwood valve less pulse jet engines are very similar to the ram jet engines in construction but this can be started statically without supersonic air velocities to start as in case of the ram jet engines.

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