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Design of Valve Less Pulsejet Engine

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***Abstract*: Pulse detonation engines also known as pulse jet engines are categorization of internal combustion engine that eliminate the key component present in the rest of the jet engine i.e. compressor and turbine. The entire internal combustion engine is less efficient. Having few to almost no moving parts such jet engine could become the next technology in the field of aviation and space technology. Though this technology was first observed in the mid-20th century. Using the geometry as the huge factor for producing thrust through the intake and exhaust pipe, pulse jets rely on the compressibility of intake air and the type of fuel for better combustion efficiency.**

***Keywords*: pulse jet engine, detonation, valve less, combustion, thrust.**

1. Introduction

A pulse jet engine is a type of engine that produces power in the form of pulses. A pulsejet engine is made up almost few moving parts and it does not need forced induction of air for intake. Pulse jet engines are the very lightweight form of jet propulsion, but usually has a poor compression ratio. A pulse jet engine is essentially a shallow tube that utilizes sound waves to induce fuel and produce thrust. Pulsejet engine is one of the simplest form of air breathing propulsion ever developed. Pulsejet engines have few moving parts making them economical to construct and maintain. These are scalable light weight, low cost and fairly efficient at converting fuel to heat and thrust and there are no such things as a “misfire” in a pulsejet. These advantage make them ideal for used in Unmanned Aerial Vehicles (UAV’s).

A pulse combustor, commonly known as the pulsejet is one of the simplest propulsion devices. Its operation requires no moving parts unlike other air breathing propulsion devices. Their simple structure and light weight make them an ideal thrust generation device, but thermodynamic efficiency is very low as compared to gas turbine engines due to the lack of mechanical compression. Due to low efficiency, the pulsejet receives little attention after the late 1950s. However, with pulsejet no moving parts may be advantageous for building smaller propulsion devices due to some specific advantage over conventional engine. The thermodynamic efficiency of conventional engine decreases non-linearly with decreasing characteristic engine length scale. Also, small scale engine with moving parts are more prone to breakdown due to fatigue of the moving element. Figure 1 schematic of a pulsejet engine. There are two main types of pulsejet engine – the valved and valveless pulsejet engines. Valved engine uses a mechanical valve to control the injection of fresh charge of fuel and air. They force the hot gases to go out the back of the engine through the tail pipe only, and allow fresh air and more fuel to enter through the intake. The other type of pulsejet is valveless pulsejet as depicted in figure 1, which has no moving parts and uses only their geometry to control the flow of inlet and exhaust gases. Valveless engine expel exhaust gases out of both the intakes and tailpipe, with majority of exhaust gases going out through the longer tailpipe for more efficient propulsion. The pulsejet repeats its pulse combustion sequence at a given frequency. The resonance frequency, among other factors, depends on the length of the engine, mass flow rate and peak temperature. The efficiency of design depends on the compressibility of the intake air and exhaust gases.

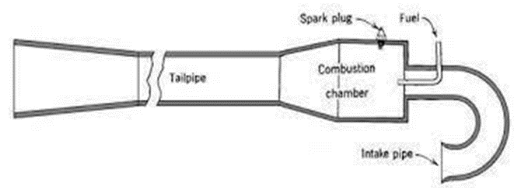

Fig. 1. Schematic of a pulse jet engine

2. Working Principle

A valve less pulse jet engine has a chamber with tube like ports of unequal length diameter and length. One port curved backwards is the inlet ports and the other is the tail port both ports points in the same directions. When the fuel air mixture enters in the combustion chamber and gets ignited the pressure rises suddenly the rising pressure forces the hot gas out and passes through the port at high speed. As it leaves the engine the hot gas produces thrust. As the gas expands the pressure inside the chamber drops. Due to inertia, expansions continue even after the pressure is at atmospheric level. At the lowest point there is partial vacuum in the chamber at this point the momentum of the expanding gas is spent and the expansion stops.

The process reverses itself and fresh air start entering in to the end of inlet port. At the intake side it quickly passes through the tube, enter the chamber and mixes with fuel. In a pulse jet engine, it happens 100 to 250 times per second. This happens

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so fast that it resembles an explosion.

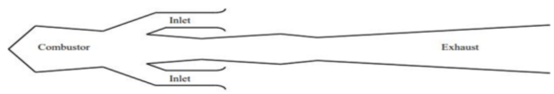

Fig. 2. Pulse jet engine

Paul Schmidt and jean Henry bartin tested a number of design featuring concave ring in the intake which offered grate resistance to backflow but let fresh air in. In the j shaped and u shaped valve less engine the hot gas is flow out of two ports. It does not matter because they both face in the same direction. The tail pipe is rather longer than the intake so it takes incoming air longer to reach.

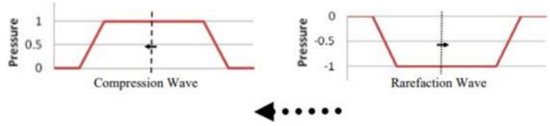

Fig. 3. Wave operations

The longer length of the tail pipe is important as it prevents oxygen entering from the wrong way it does this because the pulse ignites there is still some exhaust gas in the tail pipe. This is sucked in before any additional oxygen is sucked in.

Some valveless engine designers have developed design that are not bent backwards but employ various tricks that work in a similar way to valves that they allow fresh air to come in but prevent the hot gas from getting out through the intake.

3. Operating Principle

The valve pulse jet engine is the simplest engine that can run statically. It has three main components viz. intake, combustion chamber and exhaust. The process begins with ignition of the air fuel mixture in the combustion chamber. This is technically deflagration and not an explosion. The difference being rapid burring vs detonation. The deflagration causes rise in temperature, pressure and compression wave. This compression wave travels down both inlet and exhaust duct at the speed of sound.

The heat addition causes the air to expand and begin flowing down the duct. In the inlet the air mass rapidly accelerated outward behind the pressure wave while the exhaust duct reacts more slowly.

To start the common name of “valve less pulse jet” is a misnomer. While it certainly has neither mechanical valve nor any moving parts for that matter, it does have aerodynamic valves. The simplest of these consisting of an intake port that is smaller than the exhaust. The technical name for this type of pulse jet is acoustic type pulse jet of aerodynamically valve pulse jet will be referred to throughout this paper simply as a valve less pulse jet.

The valve less pulse jet is the simplest jet engine that can run statically. It is composed of three main components the intake, combustion chamber and the exhaust. The no steady intermittent process begins with the ignition of the fuel air mixture in the combustion chamber. This is technically deflagration and not an explosion. The difference lies in quickly burning verses detonation. The deflagration wave travels down both the inlet and exhaust ducts, at the speed of sound.

The smaller air mass of the inlet is rapidly accelerated outwards behind the pressure wave while the larger exhaust duct reacts more slowly. When the compression wave reaches the end of each tube it is reflected in the opposite direction as a low pressure rarefaction wave. This happens first in the shorter, smaller inlet and then in the exhaust. The rarefaction wave in the inlet is relatively weak but the flow still reverses first in the inlet due to its smaller air mass and preloads it with fresh air. The hot combustion gases continue to flow down and out the

Table 1
Literature Survey

S. No.	Author and year of publication	Methodology/Basic principles	Scope of work/conclusion
1	Fabrication and Performance Analysis if Valve Less Engine. Tarakaram, K.S.D.P. Pavan Kumar, B. Purna Chandra Rao, V. Nagarjuna 2019	The main objective in the project is to fabricate and conduct the performance test on Impulse Jet Engine. The pulse jet used in this study is valve less pulse jet working on LPG fuel cited by Bruce Simpson. Some major modifications were made to exhaust tail pipe and U bend, and further more engine’s thrust power was scaled down to 9lbs from 55lbs.	From analysis, it is clear that heat loss through exhaust gases is very high when compared to any other heat loss. So, to obtain more thrust power, heat loss through exhaust gases has to be minimized. Though noise and vibrations are common in any engineering device, this engine is producing much critical noise and vibrations which are beyond the limit. Making some modifications to the design and adding some components to absorb vibrations may bring good results.
2	Combustion of Acetylene and its Performance in Valve Less Pulse Jet Engine. M. Dhananiya Lakshmi Sri, L. Oblisamy, G. Mari Prabu 2016	This paper summarizes the significance of barriers Involved in using acetylene as alternate fuel for valve less pulse jet engine. Acetylene gas produces 2210 to 3300 degree Celsius temperatures when allowed to combust with atmospheric air. The idea of high temperature Engines are innovatory due to water which could a company the combustion of acetylene.	In the present study computations were carried out for valve less pulsejet model with fuel as kerosene and acetylene. With kerosene as fuel the proper combustion occurs in combustion chamber, but air and fuel does not Mix properly. With acetylene as fuel the temperature is very high In combustion chamber but acetylene has less density when compared to kerosene hence acetylene mixes with air better than kerosene.
3	Valveless Pulse Jet Engine Pradeep L, Navinesh B 2018	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.	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.

exhaust duct even as the rarefaction wave travels back towards the combustion chamber.

The reduction of heat edition from the end of combustion and the arrival of the rarefaction wave in the combustor causes a pressure drop below ambient. Now the engine truly breathes and the fresh air is drawn in the inlet into the combustion chamber. The inertia of the exhaust gases kept them flowing out the exhaust even as air was already flowing in the inlet. The rarefaction wave is partially reflected from the end of the combustor and transmitted back towards the exhaust staying a rarefaction wave.

4. Design and Manufacturing

The design of valve-less pulse jet engine is based upon the design of Lockwood and Hiller, they developed U-shaped engine that claimed to have an extremely high thrust to weight ratio (Lockwood, 1952). They experimented with many ways to increase the thrust as well as to reduce the weight of the engine that is to make light weight engine.

5. Conclusion

The valve less pulsejet engine can be an alternate solution for propulsion of target drones and unmanned Ariel vehicle after some more improvements in the pulsejet research. Valve less Pulsejet Engine was fabricated and its performance was studied. In present work, thrust power at various fuel supply rates was calculated and it was found that thrust power is increasing linearly with increase in fuel flow rate. Various losses such as heat loss through exhaust gases, heat loss through Convection and Radiation were calculated and furnished in the form of heat balance sheet.

It is clear that heat loss through exhaust gases is very high when compared to any other heat loss. So, to obtain more thrust power, heat loss through exhaust gases has to be minimized. Though noise and vibrations are common in any engineering device, this engine is producing much critical noise and vibrations which are beyond the limit. Making some modifications to the design and adding some components to absorb vibrations may bring good results.

References

[1] Tarakam, B. Purana Chandra Rao, "Fabrication and Performance Analysis if Valve Less Pulse Jet Engine, 2019.
[2] Gwynn, J., The history of the Pulse Jet, 2005.
[3] M. Dhananiya Lakshmi Sri, L. Oblisamy, G. Mari Prabu, Combustion of Acetylene and its Performance in Valveless Pulse Jet Engine, 2016.
[4] Heerbeek, P. A, "Mathematical modelling of a pulse combustor of the Helmholtz type, M. S. Thesis, 2008.
[5] K. Sainath, Ruhail Masood, Mohd. Salahuddin, Md. Ismail, Mohd. Khaleel Ullah, "An investigation report and design of pulse jet engine," 2014.