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Design and Optimization of Valveless Pulsejet Engine

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ABSTRACT
Simple design and efficiency make pulsejet engines attractive for aeronautical short-term operation applications. An active control system extends the operating range and reduces the fuel consumption considerably so that this old technology might gain a new interest. During the operations of these pulsejet engines the surfaces of engine will get more heated. In order to cool the engine surface and to get more thrust we have attached an additional component called secondary inlet in that valve less pulsejet engine. The pulsejet is the only jet engine combustor that shows a net pressure gain between the intake and the exhaust. The pulsejet is the only jet engine combustor that shows a net pressure gain between the intake and the exhaust. We choose the LOCKWOOD's design of pulsejet engine. By using the CFD analysis we have analysed the modified design of valveless pulsejet engine. This project provides an overview of this unique process and the results of these design modifications are reported.
Keywords **-** pulse jet engine, cool-down system, lockwood design, valveless type

I. INTRODUCTION

Modern jet engines, like the ones found on large passenger aircraft or military fighters are incredibly complex and expensive to make. Built from thousands of individual parts, many of which are made from exotic alloys like titanium and Inconel, these engines are a masterpiece of modern engineering. But there is one type of jet engine that has been around for almost 100 years, can be built$ out of plain old steel using simple tools, and in some cases has no moving parts at all. Well it's true and of course it is the pulsejet.

II. VALVELESS PULSEJET

WHY VALVELESS:

- The ordinary pulsejet is already a very simple engine.
- It is just a piece of tube cut to the required dimensions, with a few small flaps and a fuel jet at one end.
- So, one might ask, why go that one small step further and eliminate the valves? The prime reason is that the use of flap valves limits the reliability and longevity of the engine.
- A Valveless pulse jet is one of the simplest jet propulsion devices ever designed, and is the simplest form of jet engine that does not require forward motion to run continuously.
- Valveless pulsejets are low in cost, light weight, powerful and easy to operate.
- They have all the advantages (and most of the disadvantages) of conventional valved pulse jets, but without the troublesome reed valves that need frequent replacement.
- A valve less pulsejet can operate for its entire useful life with practically zero maintenance.

THE ADVANTAGES OF VALVELESS PULSEJET:

- Theoretically the pulse jet engine has higher fuel efficiency than a normal jet engine that keeps constant pressure.
- Intermittent rather than constant fuel combustion is another key factor in making the pulse-jet engine more fuel efficient, than ordinary.
- Engines can be produced in many sizes with many different thrust outputs ranging from a few pounds to thousands of pounds.
- They have a very high thrust-to-weight ratio, which means a lighter engine producing more pounds of thrust than its weight.
- They are mechanically very simple and have very little moving parts.
- Self-compressing.
- The pressure inside the combustor raises steeply, which increases combustion efficiency.
- The pulsejet is the only jet engine combustor that shows a net pressure gain between the intake and the exhaust.
- Pressure gain across the combustor, rather than loss.
- a 5-percent gain in combustion pressure achieved by this method gives about the same improvement in overall efficiency as the 85-percent gain produced by a compressor, all other things being equal.

THE DISADVANTAGES OF VALVELESS PULSEJET:

- A big problem is that the gain in efficiency offered by pulsating combustion is not at all easy to utilize for propulsion.
- Unsteadiness generates loss.
- Pulsations are dangerous for the brittle axial turbine blades.
- For the same engine bulk, you get less thrust than with the competing jet engines.
- The pulsations produce horrible noise and mad vibration.

III. CONSTRUCTION

- The picture below shows one of the many possible layouts of a valve less pulsejet engine.
- It has a chamber with two tubular ports of unequal length and diameter.
- The port on the right, curved backwards, is the intake pipe. The bigger, flared one on the left is the exhaust, or tailpipe.
- In some other engines, it is the exhaust pipe that is bent into the U-shape, but the important thing is that the ends of both ports point in the same direction.

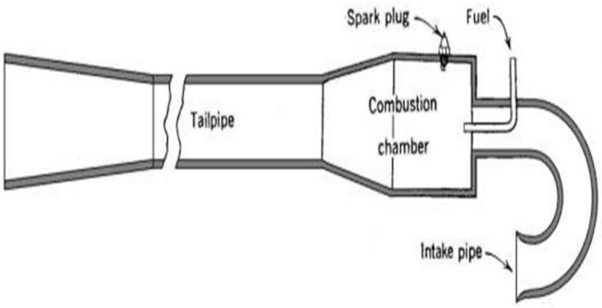

Fig1: Construction of a pulsejet engine

IV. OPERATION

The Kadenacy effect:

The Kadenacy effect is an effect of pressure-waves in gases. It is named after Michel Kadenacy who obtained a French patent for an engine utilizing the effect in 1933.

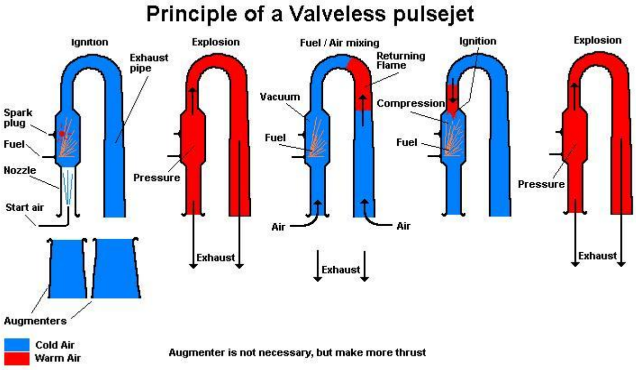

Fig 2: Operation of a pulsejet engine.

There are also European and US patents. In simple terms, the momentum of the exhaust gas leaving the cylinder of an internal combustion engine creates a pressure-drop in the cylinder which assists the flow of a fresh charge of air, or fuel-air mixture, into the cylinder. The effect can be maximized by careful design of the inlet and exhaust passages.

V. WORKING

When the fuel-air mixture combusts in the chamber, the process generates a great amount of hot gas very quickly. This happens so fast that it resembles an explosion. The immediate, explosive rise in internal pressure first compresses the gas inside and then pushes it forcefully out of the chamber.

Two powerful spurts of hot expanding gas are created – a big one that blows through the tailpipe and a smaller one blowing through the intake. Leaving the engine, the two jets exert a pulse of thrust – they push the engine in the opposite direction.

As the gas expands and the combustion chamber empties, the pressure inside the engine drops. Due to inertia of the moving gas, this drop continues for some time even after the pressure falls back to atmospheric. The expansion stops only when the momentum of the gas pulse is completely spent. At that point, there is a partial vacuum inside the engine.

The process now reverses itself. The outside (atmospheric) pressure is now higher than the pressure inside the engine and fresh air starts rushing into the ends of the two ports. At the intake side, it quickly passes through the short tube, enters the chamber and mixes with fuel. The tailpipe, however, is rather longer, so that the incoming air does not even get as far as the chamber before the engine is refilled and the pressure peaks.

One of the prime reasons for the extra length of the tailpipe is to retain enough of the hot exhaust gas within the engine at the moment the suction starts. This gas is greatly rarified by the expansion, but the outside pressure will push it back and increase its density again. Back in the chamber, this remnant of previous combustion mixes vigorously with the fresh fuel/air mixture that enters from the other side. The heat of the chamber and the free radicals in the retained gas will cause ignition and the process will repeat itself. The spark plug shown on the picture is needed only at start-up. Once the engine fires, the retained hot gas provides self-ignition and the spark plug becomes unnecessary. Indeed, if spark ignition is left on, it can interfere with the normal functioning of the engine.

You may wonder about the sharp transition from the intake tract into the chamber. It is necessary to generate strong turbulence in the incoming air, so that it mixes with injected fuel properly. A gentler, more gradual entry would not generate the necessary swirling of gases. In addition, turbulence increases the intensity of combustion and the rate of the heat release.

VI. COMPARISON OF VALVELESS PULSEJET ENGINE WITH RAMJET ENGINE

Table 1: Comparison of Existing and Modified Design

FACTOR	EXISTING DESIGN	MODIFIED DESIGN
THRUST (N)	126.7	154.28
MAXIMUM TEMPERATURE (K)	1773	926
MAXIMUM VELOCITY(V)	412	456.4
EFFICENCY (%)	2.637	21.80
FREQUENCY (Hz)	48.8	48.8

- Many people confuse ramjets with pulsejets and are unaware that although both are quite simple and somewhat similar in design, they vary significantly in the way they operate and the tasks for which they are suitable.
- Ramjets have no moving parts -- much like a valve less pulsejet but they operate with continuous combustion rather than the series of explosions that give a pulsejet its characteristic noise.
- On the face of it a ramjet would seem to be the ideal kind of jet -- no spinning turbines, no vibrating valves and a seemingly ultra-simple construction. Unfortunately there are two things that work against the ramjet:

VII. CONCLUSION

- Thus the modified design of Lockwood's pulsejet engine was analysed and the results are tabulated.
- Although there has been extensive pressure and thrust data documented in this work, there has been little work done in optimizing the pulsejet's operation based on the secondary inlet in that engine.
- By compare with the existing design of Lockwood's pulsejet engine, the modified design gives more thrust and the efficiency also increases.
- Here the exhaust temperature will decrease. So, the engine surface will not get more heated. And the expected results are came out. When testing the pulsejet for optimal thrust, the jet would need to be tested in several different modes and geometries.
- Changing the overall length of the jet, exit diameter, and exit geometry would be interesting topics to investigate.

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