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# An Investigation Report & Design of PULSE JET ENGINE

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**ABSTRACT**

*Engine may be defined as a device in which the chemical energy of the fuel is converted into heat energy and further into mechanical output .broadly engines may be classified into two types one is Automobile engines and the other is Aviation engines .one of the type is a pulse jet engine [PJE] 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 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 ]. The project is divided in two parts. The first part aims at drafting & constructing the working model of a pulse jet engine whose overall length is approximately 56 inches. Gas dynamic ,acoustics & chemical kinetics were modeled to gain an understanding of various physical phenomenon affecting the pulse jet engine operation .the pulsejet was run on valve less mode on LPG as fuel .pressure, temperature, thrust, specific impulse were the parameters of calibration and it was ground tested , And second part is to modify the nozzle at the exhaust section so as to increase the thrust of the pulse jet engine. The nozzle modification would be done by analyzing the nozzle in ANSYS software under the CFD (computational fluid dynamics) the results are accurate to practical limits. It's the simplest type of jet engine to construct but there is a lot of physics to be understood behind it.*

## THEORY

since the existence of mankind on earth he has dreamed himself to be in sky .many of them has made an attempt to do so but yet one of the great scientist Sir ISAAC NEWTON and his famous third Law "FOR EVERY ACTION THERE IS EQUAL AND OPPOSITE REACTION" Has put fantasy into reality so the development of first pulse jet engine came Into existence A pulse jet engine (or flying bomb) is a type of jet engine in which combustion occurs in pulses. Pulsejet engines can be made with some or no moving parts, and can run with any type of fuel (liquid or gaseous).pulse jet engines are light form of engines when compared to other aviation engines. but usually have a low compression ratio, and hence give a low specific impulse. one of types in a pulse jet engine is a pulse detonation engines(PDE),and which can give high compression and good efficiency. The pulse jet is mechanically very simple, but the physics behind how a pulse jet works is intriguingly complex. Pulse jet can be used to power a variety of different types of vehicles ranging from planes to racing bikes because pulse jet are so simple when compared with gas turbine people often choose to build them when they want jet power this is where people can go into problems. Although just copying a proven design is easy. designing and building your own pulse jet engine can be extremely different if you do not know how to plan & where to start from often people can be discouraged by a poor engine design I have studied every aspect about working pulse jet design and literature about the history of this type of engine. I was searching to find some type of laws or equation that governed a pulse jet engine dimensions. Yes there are many fluid flow equation which can applied to make the best pulse jet engine.

**Types of PULSE JET ENGINE**

Basically to classify there are two types of pulse jet engines. one uses the shuttering valves and the other uses the geometry to gain the process of pulsing .

**Valved Pulsejet & Its Working**

Valved pulsejet engines use a mechanical valve to control the flow of expanding exhaust, forcing the hot gas to go out of the back of the engine through the tailpipe only, and allow fresh air and more fuel to enter through the intake.

The valved pulsejet comprises an intake with a one-way valve arrangement. The valves prevent the explosive gas of the ignited fuel mixture in the combustion chamber from exiting and disrupting the intake airflow, although with all practical valved pulsejets there is some 'blowback' while running statically and at low speed, as the valves cannot close fast enough to stop all the gas from exiting the intake. The superheated exhaust gases exit through an acoustically resonant exhaust pipe. The intake valve is typically a reed valve. The two most common configurations are the daisy valve, and the rectangular valve grid. A daisy valve consists of a thin sheet of material to act as the reed, cut into the shape of a stylized daisy with "petals" that widen towards their ends. Each "petal" covers a circular intake hole at its tip. The daisy valve is bolted to the manifold through its center. Although easier to construct on a small scale, it is less effective than a valve grid.

There are two basic types of pulsejets. The first is known as a valved or traditional pulsejet and it has a set of one-way valves through which the incoming air passes. When the air-fuel is ignited, these valves slam shut which means that the hot gases can only leave through the engine's tailpipe, thus creating forward thrust.

The cycle frequency is primarily dependent on the length of the engine. For a small model-type engine the frequency may be around 250 pulses per second, whereas for a larger engine such as the one used on the German V-1 flying bomb, the frequency was closer to 45 pulses per second. The low-frequency sound produced resulted in the missiles being nicknamed "buzz bombs."

**Valveless Pulsejets & Its Working**

Valve less pulsejet engines have no moving parts and use only their geometry to control the flow of exhaust out of the engine. Valve less pulsejets expel exhaust out of both the intakes and the exhaust, though most try to have the majority of exhaust go out of the longer tail pipe for more efficient propulsion.

The valve less pulsejet operates on the same principle as the valved pulsejet, but the 'valve' is the engine's geometry. Fuel, as a gas or atomized liquid spray, is either mixed with the air in the intake or directly injected into the combustion chamber. Starting the engine usually requires forced air and an ignition source, such as a spark plug, for the fuel-air mix. With modern manufactured engine designs, almost any design can be made to be self-starting by providing the engine with fuel and an ignition spark, starting the engine with no compressed air. Once running, the engine only requires input of fuel to maintain a self-sustaining combustion cycle. The second type of pulsejet is known as the valve less pulsejet. Technically the term for this engine is the acoustic-type pulsejet, or aerodynamically valved pulsejet.

Valve less pulsejets come in a number of shapes and sizes, with different designs being suited for different functions. A typical valve less engine will have one or more intake tubes, a combustion chamber section, and one or more exhaust tube sections.

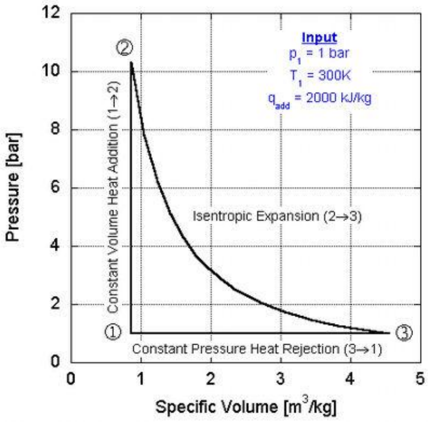
The intake tube takes in air and mixes it with fuel to combust, and also controls the expulsion of exhaust gas, like a valve, limiting the flow but not stopping it altogether. While the fuel-air mixture burns, most of the expanding gas is forced out of the exhaust pipe of the engine. Because the intake tube(s) also expel gas during the exhaust cycle of the engine, most valve less engines have the intakes facing backwards so that the thrust created adds to the overall thrust, rather than reducing it.The combustion creates two pressure wave fronts, one traveling down the longer exhaust tube and one down the short intake tube. By properly 'tuning' the system (by designing the engine dimensions properly), a resonating combustion process can be achieved. While some valve less engines are known for being extremely fuel-hungry, other designs use significantly less fuel than a valved pulsejet, and a properly designed system with advanced components and techniques can rival or exceed the fuel efficiency of small turbojet engines. In 1909, Georges Marconnet developed the first pulsating combustor without valves. It was the grandfather of all valve less pulsejets. The valve less pulsejet was experimented with by the French propulsion research group SNECMA (Société Nationale d'Étude et de Construction de Moteurs d'Aviation ), in the late 1940s.The valve less pulsejet's first widespread use was the Dutch drone Aviolanda AT-21 A properly designed valve less engine will excel in flight; as it does not have valves, ram air pressure from traveling at high speed does not cause the engine to stop running like a valved engine. They can achieve higher top speeds, with some advanced designs being capable of operating at Mach 7 or possibly higher. The advantage of the acoustic-type pulsejet is simplicity. Since there are no moving parts to wear out, they are easier to maintain and simpler to construct.

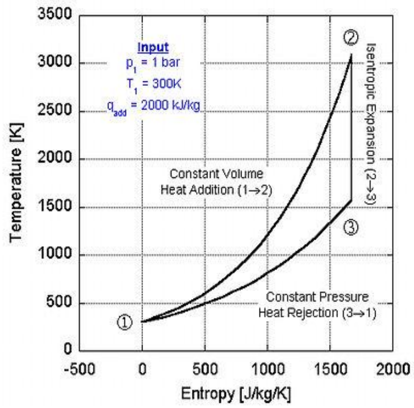
**Working cycle of a pulse jet engine based on P-v & T-s Diagram**

**All the pulse jet engines (valved or valve less) works on lenoir cycle**

**P-V & T-S diagram & calculation part of the pulse jet engine**

The following is a list of various process that occurs in a Lenoir cycle




**PV diagram** based on Lenoir cycle **TS diagram** based on Lenoir cycle

**Process (1-2) Constant volume heat addition**

The first stage of the ideal gas version of the Lenoir cycle based on the process from (1-2) involves the addition of heat in a constant volume process. This gives the following first law of thermodynamics: ${}_1Q_2 = mc_v\left(T_2 - T_1\right)$There is no work done during the process because the volume is uniformly constant: ${}_1W_2 = \int_1^2 pdV = 0$ and from the definition of constant volume (c.v) specific heats for an ideal gas process: $c_v = \frac{R}{\gamma - 1}$

Where *R* is the ideal gas constant and *γ* is the ratio of specific heats (approximately 287 J/(kg·K) and 1.4 for air respectively). The pressure after the heat addition can be calculated from the ideal gas law: $p_2V_2 = RT_2$

- **Process (2-3) Isentropic expansion** :

The following stage (2-3) involves a reversible adiabatic expansion of the fluid back to its exact pressure. It can be said that for an isentropic process that the second law of thermodynamics results in the following: by the comparing the temperature, pressure & volume as, $\frac{T_2}{T_3} = \left(\frac{p_2}{p_3}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{V_3}{V_2}\right)^{\gamma-1}$

Where $p_3 = p_1$ for this specific cycle. The first law of thermodynamics say in the following for this expansion process: ${}_2W_3 = mc_v\left(T_2 - T_3\right)$ since based on the adiabatic adiabatic process: where: ${}_2Q_3 = 0$

- **Process (3-1) Constant pressure heat rejection:**

The final stage (3-1) comprises of a constant pressure heat rejection return back to the first state. From the first law of thermodynamics we find: where: ${}_3Q_1 - {}_3W_1 = U_1 - U_3$.

From the definition of work: ${}_3W_1 = \int_3^1 pdV = p_1\left(V_1 - V_3\right)$, we recover the following for the heat rejected during this process: ${}_3Q_1 = \left(U_1 + p_1V_1\right) - \left(U_3 + p_3V_3\right) = H_1 -$ .

As a result, we can find the heat rejected as follows: ${}_3Q_1 = mc_p\left(T_1 - T_3\right)$ from the definition of constant pressure specific heats for an ideal gas: $c_p = \frac{\gamma R}{\gamma - 1}$.

The overall efficiency of the working cycle is determined by the total work over the heat input, which for a Lenoir cycle equals $\eta_{th} = \frac{{}_2W_3 + {}_3W_1}{{}_1Q_2}$ . Note that we gain work during the expansion process but lose some during the heat rejection process heat .

**Factors to consider during the design of a pulse jet engine**

The main factors that govern during the design of a pulse jet engine are temperature, pressure, melting point, strength of the weld joint and material thickness . the following are the factors discussed below in detail .

Temperature: it is defined as the degree of hotness of a body is temperature. generally expressed in degree C or F is one of the main factors of consideration as it increases the molecular state or the arrangement of the atomic structure changes . there by may cause rupture of the metal due to intense temperatures . the max temperature recorded inside the combustion chamber in a pulse jet engine is 1200 degree c .

Pressure: it is defined as the force acting per unit area is pressure, it is generally expressed in pascal. or ibf \ in^2 as rise in temperature is directly proportional to rise in pressure, so there is a need to maintain range pressure.

Melting point : its defined as the point where the solid metal starts converting to liquid . the chamber temperature is too high so you need to check that too.

Strength of weld : it is defined as the amount of force required to break a unit piece of specimen under the applied force .

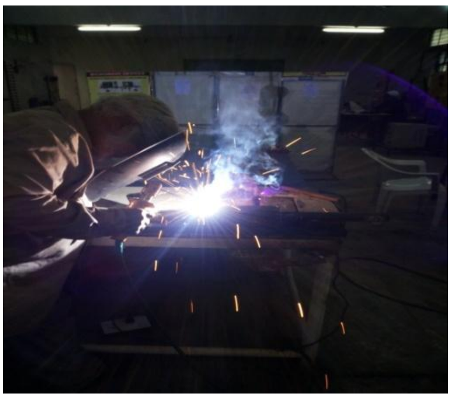
### 8.2 Material selection and properties

There are many different kinds of metals out of which the metals with there melting points is obtained, these selection of the material should be based on according to the required result & accuracy for which it to be designed and cost or the value also fetch a vital role. in general, mild steel is opted for the construction of pulse jet engines .due to ease weld & wide verities & ability

Mild steel are also termed as carbon steel which is having a high melting point of 1410 deg C (2570 deg F).However, medium carbon steel, high carbon steel have the melting temperature that ranges from 1425-1540 deg C (2600-2800 deg F).

The low carbon mixtures say (0.05-0.15%) in mild steel do not have a more effect on the melting point of cast iron, which is 1538 centigrade. considering as well as Looking at the Iron-Carbon phase diagram which shows that the decreased from this melting temperature will be only a few some of the degrees.

At higher mixtures of carbon (2-4%), as in cast iron, the melting temperature is gradually reduced. This alloy starts melting at 1154 centigrade, and is completely liquid metal at this level by 1200-1400 centigrade which depends on carbon content mixtures, Then the melting temperature of steel depends on the type of steel which are chosen in designing. Carbon steel has a melting point of 1425 degrees C to 1540 degrees C which is quite high than the usual steel.



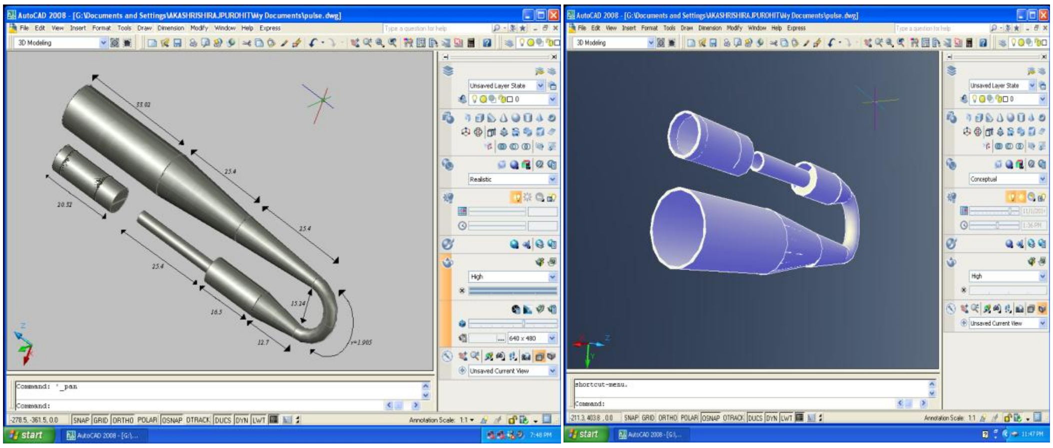
the use of the electric arc welding as for stitching before the TIG welding in the welding-section. The current was around 140. Depending on type of metal and thickness of material..

First the easy parts were joined in order to get an over view of the engine .and later tolerance parts were joined .

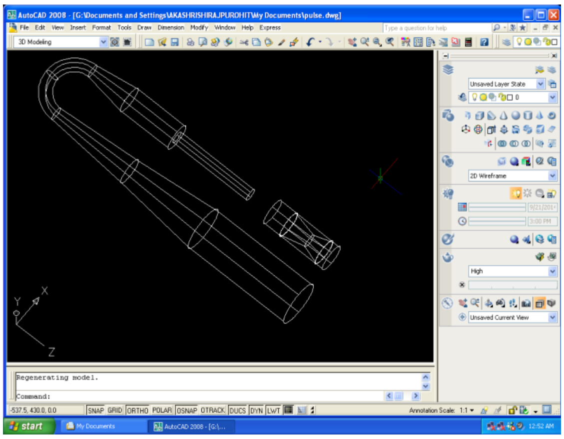
**From Drafting , Designing, Construction , Testing**

**Drafting and Designing**

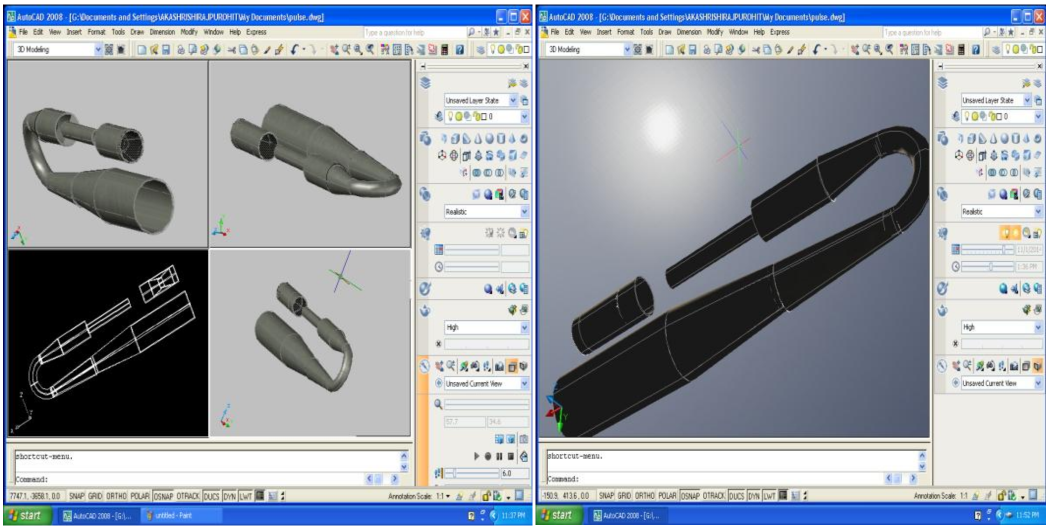
As an old saying engineers construct the world .you live with what you design. So the drafting process of our was with the held of auto cad software .which is a worlds widely used drafting software. used by the designers and engineers of present day .so we have made a 2d model & 3d too. And have used various tools of auto cad such as material selection, rendering, realistic, lights ground shadows & volume, area calculator in order to make our design near to a pratical model . first the subject is drawn in 2-D and then it is made to 3-D . computation increases as you go deep into the meshing in auto cad to make surface texture better . 3-D MODEL OF A VALVE LESS PULSE JET ENGINE



Shows a realistic view of a model.



Shows an 2-d wireframe model of a pulse jet engine with an internal nozzle view.



The above image shows a multiple view port of pulse jet engine. top left is a front view, right is a back view, bottom left is a 2-d wire frame & bottom right is an isometric view

### Construction and Fabrication

Next step to move was with the construction of prototype. So, we have selected the material for prototype as jess iron with gauge 18 which was easy to work with then we rolled the sheet according to our geometry. then we moved with the part of soldering and assembling of all the parts. & finally it was put to test. With positive results of its working as desired.

**A prototype of a valve less pulse jet engine at an initial level.**

**Advanatages and Disadvantages of the Pulse Jet Engines**

- Extreme simplicity
- Low cost of construction
- Extreme efficient combustion & very less fuel is used
- Medium to largest engines can bur almost any flammable material. However it possess some of the drawbacks as
- Its noise level is very high
- It has high radiant heat levels
- Smallest engines only successful with extremely fast burning fuels
- The engine thrust can be increased by redesigning the nozzle section, also different composite materials could be tried to construct the engine which would reduce the weight to the thrust ratio.

## RESULT

So as off we finished the construction we had moved to the ground testing of pulse jet engine . at the back area in the college campus ground to inspect the working of the project we have found that the compressor pressure maintained at 20 -50 psi used to start the process for further the fuel is introduced into the chamber and ignited and then the process starts till the state of red hot is achieved. It is the first type of internal combustion engine with such simplicity to construct & This type of engines could also be mounted on racing cars with little modification (noiseless). One of its scope is to act as a plasma generator (A 4th state of matter produced when the gas is heated to a very high temperatures as of in your CFL bulbs.

**A fir fumes during the start of a pulse jet engine**

## REFERENCES


1. Ogorelec, Bruno. "Blast Compression Valveless Pulsejet Engine (A Layman's Concept)"
2. R.L. Ordon, Experimental investigations into the operational parameters of a 50 cm class pulsejet engine, M.S. Thesis, Department of Mechanical and Aerospace Engineering, NC State University, Raleigh, NC, 27695, 2006
3. *Aeronautical Engineering Review*, Institute of the Aeronautical Sciences (U.S.): 1948, vol. 7.
4. F. Zheng, Computational investigations of high speed pulsejets, Ph.D. Dissertation, Department of Mechanical and Aerospace Engineering, NC State University, Raleigh, NC, 27695, 2009.
5. George Mindling, Robert Bolton: *US Airforce Tactical Missiles:1949-1969*: The Pioneers, *Lulu.com, 200: ISBN 0-557-00029-7*
6. Kailasanath, K., "Review of Propulsion Applications of Detonation Waves," *AIAA Journal*, Vol. 39, No. 9, pp. 1698-1708, 2000.

7. Workings of the valveless pulse jet
8. ↑ NRL pulse jet designed for defrosting
9. P.J. Litke, F.R. Schauer, D.E. Paxson, R.P. Bradley, J.L. Hoke, Assessment of the performance of a pulsejet and comparison with a pulse-detonation engine, in: Proceedings of the 43rd AIAA Aerospace Sciences Meeting and Exhibit, January 10-13, AIAA 2005-0228, pp. 2,7, 2005.
10. ↑ http://www.home.no/andreas.sunnhordvik/English/mechanical/valveless_e.htm
11. Roy, G.D., Frolov, S.M., Borisov, A.A., and Netzer, D.W., "Pulse Detonation Propulsion: Challenges, Current Status, and Future Perspective," *Progress in Energy and Combustion Science*, Vol. 30, No. 6, pp. 545-672, 2004.
12. Hoffmann, N., *Reaction Propulsion by Intermittent Detonative Combustion*, German Ministry of Supply, Volkenrode Translation, 1940.
13. Shachtman, Noah (June 24, 2008). "Explosive Engine Key to Hypersonic Plane". *Wired (magazine)* (San Francisco, California: Condé Nast Publications). Retrieved 2009-06-27.
14. "Pulse Detonation Engines", An interview with Dr John Hoke, head researcher from Innovative Scientific Solutions Incorporated PDE program under contract to the United States Air Force Research Laboratory, broadcast on New Zealand radio, 14th April 2007
15. Norris, G., "Pulse Power: Pulse Detonation Engine-powered Flight Demonstration Marks Milestone in Mojave," *Aviation Week & Space Technology*, Vol. 168, No. 7, 2008, pp. 60.
16. D.E. Smith, The synchronous injection ignition valveless pulsejet, Ph.D. Dissertation, Faculty of the Graduate School, University of Texas at Arlington, TX, 1987.
17. "Pulse Detonation Engine Flies Into History", *Air Force Print News Today*, May 16, 2008, accessed August 16, 2008