Design Of Valveless Pulsejet Engine (Lockwood Hiller)

Siddhesh M Magar[1], Prathamesh A Mahajan[2], Pranjal Banawalikar[3], Aakash Patil[4], Dilip Radkar[5]
[1, 2, 3, 4, 5] Dept of Mechanical Engineering
[1, 2, 3, 4, 5]BharatiVidyapeeth College of Engineering, Mumbai

Abstract- *With current generation, Globalization has increased to far different level. The amount of transportation of various resources, travelling of people to different places all over the world and the continuous search of life on different planets. All these things are very important. Mostly the quickest way of transportation is aerial. This includes all types of aircraft, space crafts, etc. Though all these vehicles have their various differences, one thing, which is common that drives all these vehicles, is the Engine, which is the core of everything. But all these engines come at a cost. All the engines like Turbojet engines, steam engines, etc. are expensive. Also they contain a collection of many components.*

They are very complex to manufacture. Thus the concept of pulsejet which is not only ease to manufacture but is also light weight makes lot of sense. The other main reason is that the overall efficiency of these engines is high as compared to IC engines. Also with very less mechanical parts , the mechanical efficiency of these engines also increases a lot. So in this study, some modifications like altering the length of exhaust pipe, diameter of combustion chamber, etc. are done in the design of engine.

Keywords- Pulsejet engine, combustion chamber, mechanical efficiency, LPG cylinder.

I. INTRODUCTION

Currently most of the engines like steam engines, turbo prop engines, turbojet engines, etc. are extensively used. Before the increasing popularity of all these engines, Pulsejet engines were used. Now again the reintroduction of pulsejet has caught the eye of many different people all over the world. This has led to research and development on Pulsejet engines due to various factors like low cost of manufacturing.

In addition, other advantage of pulsejet, which has a lot of importance, is that it can run on almost everything that burns, including particulate fuels such as sawdust or also powdered coal. As the amount of mechanical parts is very less, thus it also increases its mechanical efficiency.

A Pulsejet engine is the type of engine with no or a very limited number of moving parts, in which, thrust is produced in form of pulses due to combustion. It has a very simple construction process having a very low cost.

The valve less pulsejet is one of the most simplest jet engines in the world. This can be built in many different sizes, as long as the relation between the different openings is kept. This engine has no moving parts which mean it cannot undergo any type of wear. The valve less pulsejet engine uses the mass of air in the intake tube as its valve, instead of any mechanical valve. It cannot do this without moving the intake air outward, and this volume of air itself has significant mass.**[1]**

A pulsejet's operation can be explained by combining two cycles:

i) Lenoir Cycle
ii) Humphrey Cycle

A. Lenoir Cycle

The Lenoir Cycle consists of isentropic compression followed by constant volume heat addition and then adiabatic expansion.

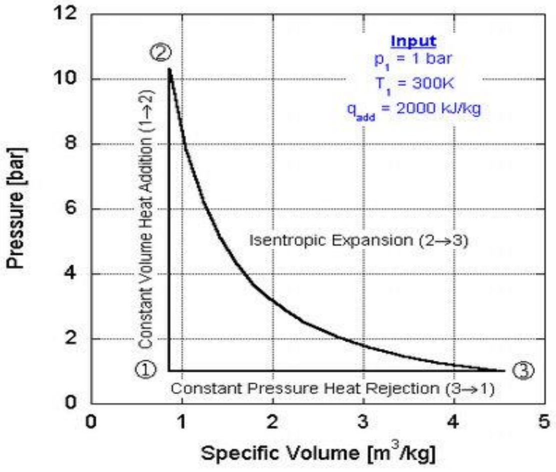
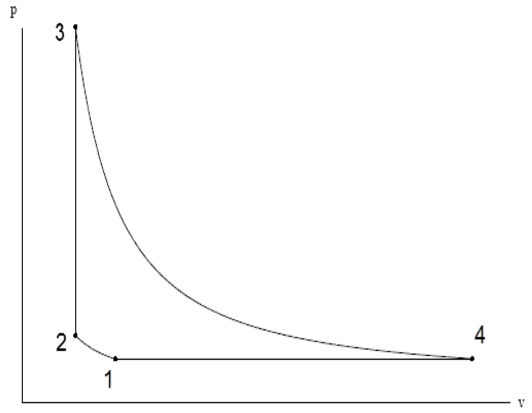


Fig1. Lenoir Cycle

The Lenoir Cycle consists of three thermodynamic processes

Process 1–2: Heat Addition at Constant volume
Process 2–3: Isentropic Expansion
Process 3–1: Heat Rejection at Constant Pressure

B. Humphrey Cycle



p–v diagram of a Humphrey cycle.

Fig 2. Humphrey Cycle

The Humphrey Cycle, operates similarly but has an isentropic compression added to the cycle. Pulsejets typically have a very small compression ratio that reaches a maximum at around 1.7. The Humphrey cycle is a thermodynamic cycle similar to the pulse detonation engine cycle.

The ideal Humphrey cycle consists of 4 processes they are:

Process 1-2: Isentropic compression
Process 2-3: Constant volume heat addition.
Process 3-4: Isentropic Expansion of the gas
Process 4–1: Constant pressure heat rejection

II. WORKING

The cycle starts with the initial air/fuel mixture in the combustion chamber being ignited by a spark or similar combustion initiator. Air is required to initiate combustion and to promote the pulsating combustion. The initial expansion of combustion chamber gas caused by combustion moves out of both intake and exhaust runners, with the pressure waves generated by the combustion rare acted at both ends. The intake runner is shorter than the exhaust so the intake wave is reflected first, drawing in the new charge of air that is mixed with the fuel**[2].**

When the deflagration begins, a zone of significantly elevated pressure travels outward through both air masses as a “compression wave”. This wave moves at the speed of sound through both the intake and tailpipe air masses. (Because these air masses are significantly elevated in temperature because of earlier cycles, the speed of sound in them is much higher than it would be in normal outdoor air) as shown in fig 1.1.

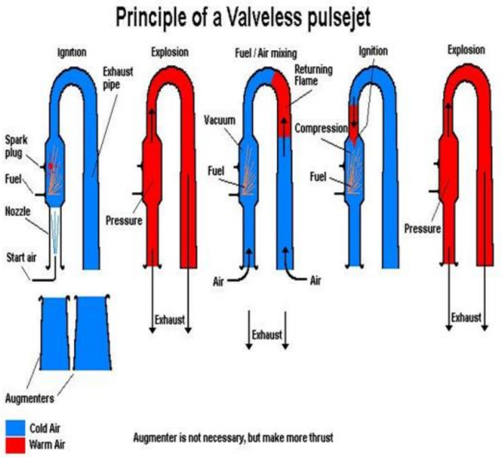


Fig 3. Principle of Valve less pulsejet**[3]**

When a compression wave reaches the open end of either tube, a low pressure rarefaction wave starts back in the opposite direction, as if "reflected" by the open end. This low pressure region returning to the combustion zone is, in fact, the internal mechanism of the Kadenacy effect, there will be no "breathing" of fresh air into the combustion zone until the arrival of the rarefaction wave.

III. METHODOLOGY

As we have discussed, even though manufacturing of Pulsejet is comparatively easy proper selection of material and management is necessary.

After researching of different materials, their strengths and other properties, we have chosen stainless steel (20 SWG) sheet metal. The other option that could have been chose was Mild Steel. However, we have chosen stainless steel due to following reasons. Along with this steel metal, 10-12 big hollow square rods and a long rectangular rod are also purchased. The sheet metal is then cut into 11 parts with help of grinding tool. The big square rods are also cut into small rods.

All the sheet metal parts are rolled. In addition, the part to be tapered is done with taper rolling. The 10 rolled part consisting of 4 tapered sections, 5 cylindrical rods and 2 elbows are now ready. Now all of these are connected with help of TIG welding. The square rods are connected in the form of pentagon again with welding. This forms the main chassis of the whole assembly.

The whole pulsejet engine is now assembled on chassis. It is placed horizontally on chassis. 3 wheels are attached to chassis with 2 wheels placed at back and the third wheel attached at the front. To these wheels bush type brakes are attached and they are controlled with handbrake. The LPG cylinder, which fuels the pulsejet, is placed at the centre part between the engines.

IV. DESIGN OF ENGINE

The dimensions of the engine were calculated as follows **[4]**.

1) $V/L = 0.00316F$
Where,
V= engine volume
L= effective acoustic length of engine
F= thrust
Converting to SI units,
$V/L= 0.000066F$ … (i)
Since $V= A_e{*}L$
A_e= exhaust area
Substituting in (i)
$A_e = 0.000066F$ ... (ii)

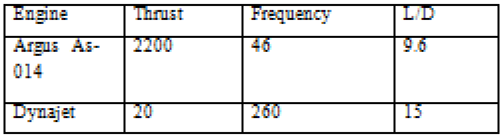
2) Weight of driver = 60Kg
Weight of pulsejet = 30Kg
Weight of trolley = 10Kg
Weight of cylinder = 7Kg
Miscellaneous weight = 5Kg
Total weight= 112Kg … (iii)

The force required to move the system is given by-
$F= \mu N$
Where,
$N= m{*}9.81$
$= 112{*}9.81$
$= 1098.7N$
$\mu= 0.3$
$\mu{*}N= 329.62N$
$\therefore F =329.62N$ … (iv)
But only 16% of the total force is required as pushing effort
$\therefore F = 0.16{*}329.62$
$F = 52.74N$ … (v)

3) Substituting in (ii),
$A_e = 0.000066{*} 52.74$
$(\pi/4){*}D^2 = 0.0035$
$D^2 = 0.0045$
$\therefore D = 0.067m$ (minimum) … (vi)

4) In our design we have taken value of diameter D = 160mm
Calculated minimum diameter = 67.08mm
∴**Design is SAFE**

5) Length of exhaust chamber



Engine	Thrust	Frequency	L/D
Argus As-014	2200	46	9.6
Dynajet	20	260	15

The L/D ratio chosen for design is –
L = 1200mm
D = 160mm
L/D = 7.5 … (vii)
$f = (\sqrt{\gamma * R * T}) / 4{*}L$
$= (\sqrt{1.36 * 287 * 1000}) / 4{*}1.2$
$f = 130.2Hz$ … (viii)

6) Combustion chamber dimensions:
$V_{\text{Combustion chamber}} \geq 0.2{*}V_{\text{engine}}$…
(A)Length of chamber = 1200mm
Smaller diameter = 65mm
Larger diameter = 260mm
$V_{\text{engine}} = \pi/3 {*}H{*} (R^2 + r^2 + R{*}r)$
$= \pi/3 {*}1.2{*} (0.16^2 + 0.065^2 + 0.16{*}0.065)$
$V_{\text{engine}} = 0.050 m^3$ … (ix)
$V_{\text{combustion}} = V_1 + V_2 + V_3$ … (x)
$V_1 = \pi/3 * 0.067 (0.235^2 + 0.1^2 + 0.235{*}1)$
$= 0.0062 m^3$
$V_2 = \pi/4 * D^2 * L$
$= \pi/4 * 0.235^2 * 0.35$
$= 0.015m^3$
$V_3 = \pi/4{*}0.085(0.235^2{+}0.065^2{+}0.235{*}0.065)$
$V_3 = 0.005m^3$
From (x),
$V_{\text{combustion}}= 0.0062+0.015+0.005= 0.0262m$
$V_{\text{combustion}}/ V_{\text{engine}} = 0.0262/0.05$
$= 0.524$

$\therefore V_{\text{combustion}} = 0.5{*}V_{\text{engine}}$ … (B)
Hence from A and B,

DESIGN IS SAFE

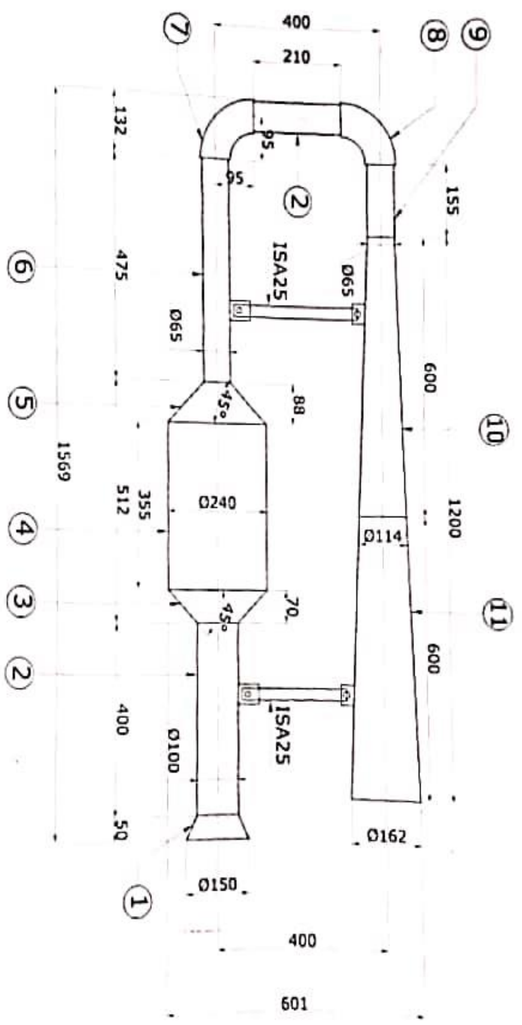


Fig. Dimensions of pulsejet engine

V. CONCLUSION

From above calculations, it is understood that efficiency and thrust may be improved by making the necessary modifications in the design.

REFERENCES

[1] Sai Kumar A., Dr.S.Srinivas Prasad "Design of Pulsejet Engine for UAV" *International Journal of Engineering Research and technology* ISSN: 2278- 0181 Vol. 3 Issue 9, September- 2014

[2] https://aardvark.co.nz/pjet/howtheywork.shtml

[3] KarthickRaja.R, Rio Melvin Aro.T "Design and optimization of Valveles Pulsejet Engine" *International journal Of Engineering research and application* ISSN:2248-9622 Vol. 4 Issue 11, November 2014

[4] Pulsejet design by C.E Tharratt, "The propulsive duct"

[5] SuganyaRose.R "Design and Analysis of Improved Pulse Jet Engine" *International journal of scientific engineering and technology research* ISSN 2319-8885, Vol.04,Issue.14 ,June-2015

[6] U.Sreekanth1,B.Subba Rao2, &Dr.A.Nagaraju, Performance and Analysis on Valveless Pulse Jet Engine, *Imperial Journal of Interdisciplinary Research (IJIR)* Vol-3, Issue-1, 2017ISSN: 2454-1362

[7] Ashish Wadhawan, Neeraj Mehta, "Development in the performance of the Valveless Pulse Jet Engine", Vol. 1, issue 3, April 2012, ISSN: 2251-8843.