

U-type Pulsejet Engine

S. Sahoo¹, P. Behera², S. Dash³, S. K. Samal^{4*}

¹Student, Aeronautical Department, Bhubaneswar Engineering College, Bhubaneswar, Odisha, India.

²Student, Aeronautical Department, Bhubaneswar Engineering College, Bhubaneswar, Odisha, India.

³Assistant Professor, Aeronautical Department, Bhubaneswar Engineering College, Bhubaneswar, Odisha, India.

⁴Professor, Aeronautical Department, Bhubaneswar Engineering College, Bhubaneswar, Odisha, India.

Email: sangram483@yahoo.com

*Corresponding Author

Abstract: Ever since the Wright brothers have invented the piston engine airplane in 1903, tremendous amounts of time and effort were put into researching to build airplanes. With time the design had changed and the propulsion medium were developed. The desire for hypersonic flight necessitated the supersonic combustion ramjet engine potentially expanding the speed envelope to the Mach 7 range. The pulse jet work without any rotation device like compressor and turbine. Also it does not have any separate enclosed chamber for combustion. In this report we it is discussed about Ramjet Engine. This include history of Ramjet engine along with the important time stamps where the ramjet engine had grown. Also it is discussed about working principle of Ramjet along the operational mechanism. And a ramjet model was fabricated and the calculation were made for this model.

Keywords: Ramjet, Thrust, Weight to power ratio.

I. INTRODUCTION

A pulsejet is a air breathing jet engine which is used to provide thrust without an axial compressor and turbine. Pulsejet can produce the thrust from static whereas ramjets cannot produce thrust at zero airspeed. Ramjet cannot move the aircraft from a zero velocity. In case of ramjet requires an additional takeoff machine like a rocket or some other machine which can assist to accelerate it to a required speed. After this it generate a thrust. But in case of pulse jet it does not require any additional device to acceleratem because it can produce thrust from zero velocity. This type of engine can operate up to speeds of Mach 6 (4,600 mph; 7,400 km/h) [1].

A history of high-speed air breathing propulsion ramjet engines and their respective vehicle and weapon systems developed under the support of the U.S. Navy is presented.

These include surface- and air-launched subsonic combustion ramjets, supersonic combustion ramjets (scramjets), and mixed-

cycle ramjet / scramjet / rocket engines intended primarily for missile applications for flight speeds from Mach 2 to Mach 8 [2].



Fig. 1: Ram Jet Engine

Fonó submitted his invention to the Austro-Hungarian Army, but the proposal was rejected [5].

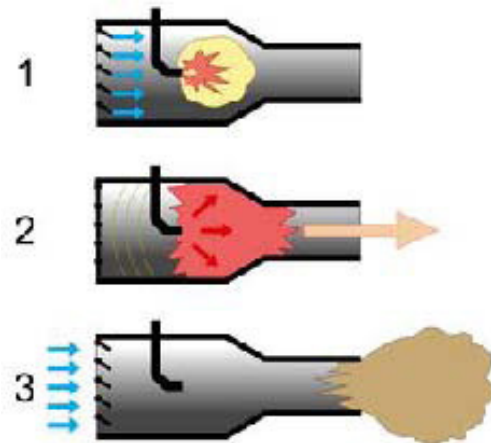


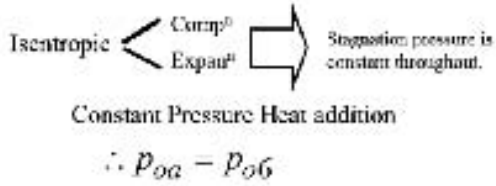
Fig. 2: Diagram of Pulsejet Engine

The ramjet Gorgon IVs, made by Glenn Martin, were tested in 1948 and 1949 at Naval Air Station Point Mugu [3]. The

Thrust

$$F = (\dot{m}_a + \dot{m}_f)C_f = \dot{m}_a C_a \quad \text{--- (1)}$$

$$= \dot{m}_a [(1 + f)C_f - C_a]$$



Ignoring variation of R, g throughout

$$\left. \begin{aligned} \frac{P_{0a}}{P_a} &= \left(1 + \frac{\gamma - 1}{2} M_a^2\right)^{\gamma/\gamma - 1} \quad \text{--- (2)} \\ \frac{P_{06}}{P_6} &= \left(1 + \frac{\gamma - 1}{2} M_j^2\right)^{\gamma/\gamma - 1} \quad \text{--- (3)} \end{aligned} \right\} \begin{aligned} &\text{where} \\ &M_a = \text{Flight Mach No.} \\ &M_j = \text{Exit Mach No.} \end{aligned}$$

with $p_j = p_a$ ($p_6 = p_a$)

we have, $M_j = M_a$

$$\therefore C_j = \frac{a_j}{a_a} C_a$$

$$\text{or, } C_j = \sqrt{\frac{T_j}{T_a}} C_a \quad \text{--- (4)}$$

Also for

$$\left. \begin{aligned} M_j &= M_a \\ C_j &= \sqrt{\frac{T_{04}}{T_{04}}} C_a \quad \text{--- (5)} \end{aligned} \right\} \begin{aligned} \frac{T_{0a}}{T_a} &= \left(\frac{P_{0a}}{P_a}\right)^{g-1/\gamma} \\ \frac{T_{06}}{T_6} &= \left(\frac{P_{06}}{P_6}\right)^{g-1/\gamma} \end{aligned}$$

Now,

$$(\dot{m}_a + \dot{m}_f)_{04} = \dot{m}_a h_{04} = \dot{m}_f Q_f \quad \therefore P_{0a} = P_{06}$$

$$\dot{m}_a [(1 + f)h_{04} - h_{04}] = \dot{m}_f Q_f \quad \text{and } p_a = p_6$$

$$(1 + f)h_{04} - h_{02} = fQ_f \quad \therefore \frac{T_{0a}}{T_a} = \frac{T_{06}}{T_6}$$

$$\therefore f = \frac{(T_{04}/T_{0a}) - 1}{\frac{Q_f}{C_p T_{0a}} - \frac{T_{04}}{T_{0a}}} \quad \text{--- (6)} \quad \text{or, } \frac{T_6}{T_a} = \frac{T_{06}}{T_{0a}} = \frac{T_{04}}{T_{0a}}$$

From (1),

$$\begin{aligned} \frac{F}{\dot{m}_a} &= (1 + f)C_f - C_a = C_a \left[(1 + f) \frac{C_f}{C_a} - 1 \right] \\ &= M \sqrt{rRT_a} \left[(1 + f) \sqrt{\frac{T_{04}}{T_{0a}}} - 1 \right] \quad \text{--- (7)} \end{aligned}$$

$$\text{Now, } \frac{T_{04}}{T_{0a}} = \frac{T_{04}}{T_a} \cdot \frac{T_0}{T_{0a}} = \frac{T_{04}}{T_a} \cdot \frac{1}{1 + \frac{\gamma - 1}{2} M_a^2}$$

$$\therefore \sqrt{\frac{T_{04}}{T_{0a}}} = \sqrt{\frac{T_{04}}{T_a} \left(1 + \frac{\gamma - 1}{2} M_a^2\right)^{-1/2}}$$

$$\therefore \frac{F}{\dot{m}_a} = M \sqrt{rRT_a} \left[(1 + f) \sqrt{\frac{T_{04}}{T_a} \left(1 + \frac{\gamma - 1}{2} M_a^2\right)^{-1/2}} - 1 \right] \quad \text{--- (8)}$$

and

$$TSFC = \frac{\dot{m}_f}{F} = \frac{f \dot{m}_a}{F} = \frac{f}{F/\dot{m}_a}$$

Actual Thrust

$$F = (\dot{m}_a + \dot{m}_f)C_f - \dot{m}_a C_a + A_j (p_j - p_a)$$

$$\therefore \frac{F}{\dot{m}_a} = [(1 + f)C_f - C_a] + \dot{m}_f \frac{A_j (p_j - p_a)}{\dot{m}_a}$$

IV. CONCLUSION

As shown in this report, the inlet should work effectively for providing the desired pressure and airflow speed to the combustor portion of the ramjet engine. The inlet should be redesigned with proper inlet area and compression ratio to minimize the use of air compressor. Next, the fuel that we were working with was not appropriate for the engine. It was not combusting properly as a result it was not giving a periodic combustion chain. So the ramjet is to be run with proper fuel and the fuel to air ratio should be accurate so that the fuel could expand easily when ignited and meet the requirement of periodic combustion chain.

Thirdly, the inlet adjusted to ensure successful start to the engine. For future work, it would be beneficial to use a low pressure air compressors like leaf blower to slow the airflow instead of the industrial grade high pressure air compressor currently used. This would result in a higher pressure recovery for the inlet and better property values for the combustor. Above were the conclusion made after the completion of fabrication of Ramjet Engine. During the theoretical study of the topic we made following conclusion on comparison of ramjet with other engine used in aerospace.

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