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A Review on Jet Powered Aircraft Engine

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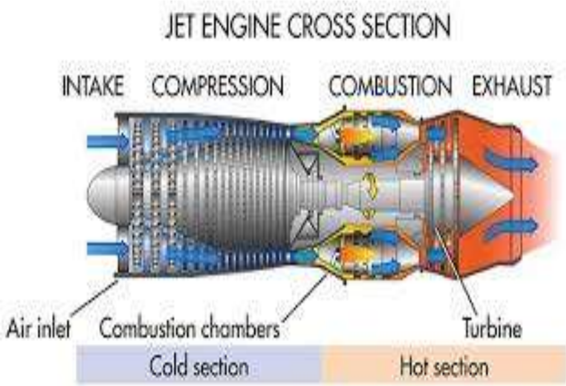
Abstract - *Jet engines can be effectively defined as a propulsion engine that compresses the inlet air to high pressure and then allowed to mix with the fuel so that combustion takes place in the combustion chamber due to high temperature. As a consequence of this combustion the turbines rotate so that the high pressure air fuel mixture is expanded and then channelized through a nozzle to achieve propulsion. This process reacts in a cyclic way since the turbine and the compressor are interconnected by means of a shaft so that when the turbine rotates due to expansion, it eventually makes the compressor to work. This helps in achieving the necessary thrust required to uplift an aircraft. Therefore this paper is considered to be a review on jet powered aircraft engines which concentrates more on its operation, ignition, power requirements and efficiency when incorporated in aircrafts and serves as an overview of the functioning of jet engines*.

Key Words: **Jet engine, shaft, propulsion, compressor, turbine, combustion chamber, nozzle, gas turbine engine, thrust, aircraft**

1. INTRODUCTION

The jet engines actually came into existence during World War II until then they were just subjected to experiments in labs. Hans von Ohain, a young German physicist was the first to design an operational jet engine which flew on August 27, 1939. Although Frank Whittle of Great Britain was the one who was credited as he registered a patent for Turbojet engine in the year 1930. But he didn't test the engine until 1941. The working principle of jet engines can be explained simply by stating that a specifically lower mass of air is accelerated to a very large velocity which results in the development of required thrust to run an aircraft. Jet engine is a type of gas turbine engine which follows the basic principles and functioning of an internal combustion engine. Air from the inlet is compressed effectively to reach high pressure using a compressor and the fuel is injected into the combustion chamber. The air fuel mixture necessarily generates the power required to run the turbine by undergoing combustion. Now the expansion of the mixture powers the turbine to run the compressor interconnected by means of a shaft. The remaining expansion takes place in the nozzle for the purpose of accelerating the gas to higher velocity which in turn produces the necessary thrust. Even at high speeds and relatively higher altitudes, jet engines have the ability to provide a larger value of thrust horsepower. The thrust required for the take off of an aircraft while using a jet engine is considerably low. To overcome this difficulty Turbofan engines came into existence which bridged the gap between a regular jet engine and propulsion engine. Turbofans are capable of efficiently converting fuel into thrust because of the production of low pressure energy over a larger fan disk area.

Hans von Ohain



Cross section of Turbojet Engine

2. OPERATION OF A JET ENGINE

The thrust developed in a jet engine is solely dependent on the quantity of fuel that is being injected into the combustion chamber. The power in the turbojet or turbofan engine is controlled by a single thrust lever since other control functions of the engine are automated. Owing to the internal temperature and other related conditions of the engine a device called electronic engine control monitors and meters the fuel flow into the combustion chamber by the action of thrust levers which are connected to this system. As far as jet engines are considered each rotating section is monitored by a gauge which measures the speed of rotation. With respect to the location of gauges they are named as follows,

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2.1 Exhaust Gas Temperature (EGT): the temperature of the exhaust gas which is let out after flowing through the turbine.

2.2 Turbine Inlet Temperature (TIT): the temperature of the gas which is at the verge of entering the turbine so as to undergo expansion. This is considered to be the highest temperature since it is directly from the combustion chamber after mixing with the fuel and is difficult to measure.

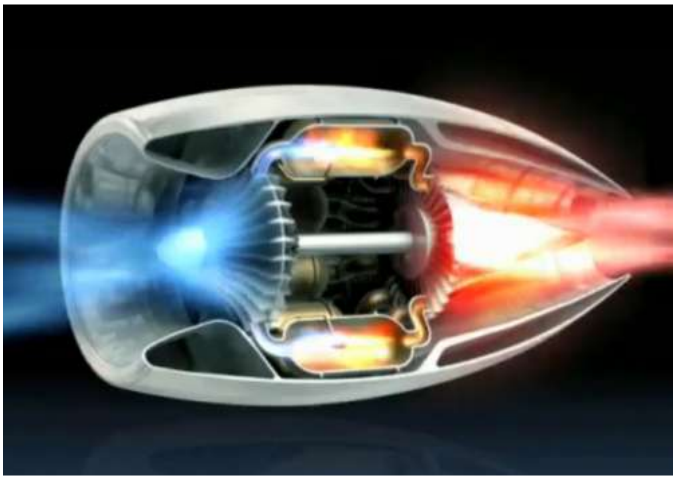
2.3 Interstage Turbine Temperature (ITT): the temperature of the gases between the high pressure turbine that is the beginning of the turbine and the low pressure turbine that is at the end of the turbine. In jet engines there are more than one turbine.

2.4 Turbine Outlet Temperature (TOT): the temperature of the gas at the outlet of the turbine after expansion when channelized to the nozzle.

RPM Gauges of Jet Engine

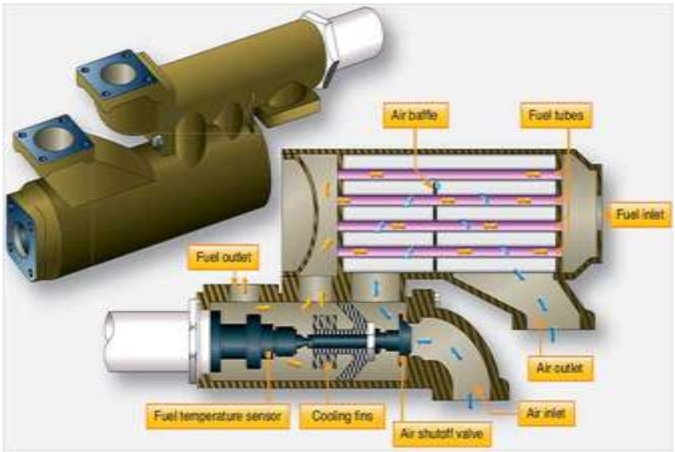
3. IGNITION OF JET ENGINE

For initial ignition an SI engine uses a spark plug. Similarly jet engines comprise of two igniter plugs which are used to initiate the engine to run from the ground. Once the engines are started the igniters are turned off and the combustion continues the remaining process of burning. Generally the engine tends to run smoothly when the flow of intake air is significantly normal. But at times there are chances for the airflow to be unintentionally affected by the wings which is primarily caused due to pitching movements of the aircraft as a consequence of turbulence and abnormal ambient conditions. To avoid such engine flameout conditions primarily caused due to turbulence, stall and bird strike, a system called **continuous ignition** is incorporated. This system can be switched on when there is enough possibility for an engine malfunction to occur due to natural calamities. Specifically in jet engines these are switched on during take-off and landing as a precautionary measure whenever there arises a warning for stall.



Ignition in Jet Engine

Along with continuous ignition there is one more device to be addressed which is called a **fuel heater**. As the aircraft flies through extremely cold conditions there is a high risk of fuel in aircraft to freeze and also can be mixed up with water molecules so that they are efficient enough to get clogged in the fuel filters specifically when the aircrafts are flying at relatively higher altitudes. In order to avoid such dangers automated devices called as fuel heaters are available in jet engines which efficiently maintain the temperature of the fuel at desired level even at extremely cold conditions. These can also be manually operated.



Fuel Heater in Jet Engine

4. POWER SETTING OPERATIONS

The thrust in the jet engine is generally indicated by a special device called **Engine Pressure Ratio** (EPR) gauge. In other words the pressure measured using an EPR gauge can be defined as the difference between the inlet pressure of the engine and the outlet pressure of the turbine. It indicates how the engine has processed the air that has been let in through the inlet. EPR gauges play a pivotal role in enabling power settings of a jet powered aircraft. When the turbofan jet engines are taken into account, the thrust in the engine primarily relies upon the fan speed of the turbo fans. These are also provided with a gas generator turbine tachometer which is employed for starting the engine and other system functions. The initial power setting is achieved by engaging the thrust levers at adequate pressure either measured using EPR gauge or in relation with the speed of turbofan. EPR gauge acts as a compensation device.

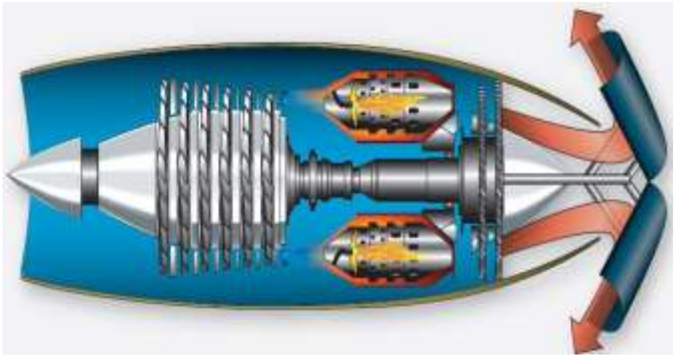
Engine Pressure Ratio (EPR)

In jet engines the relationship between thrust and the thrust levers is established by the proportionality that exists between thrust and the speed (rpm) along with thrust and temperature. This supports the efficiency to be increased at a relatively higher rpm and temperature. Therefore more thrust is produced by increasing the throttle movement.

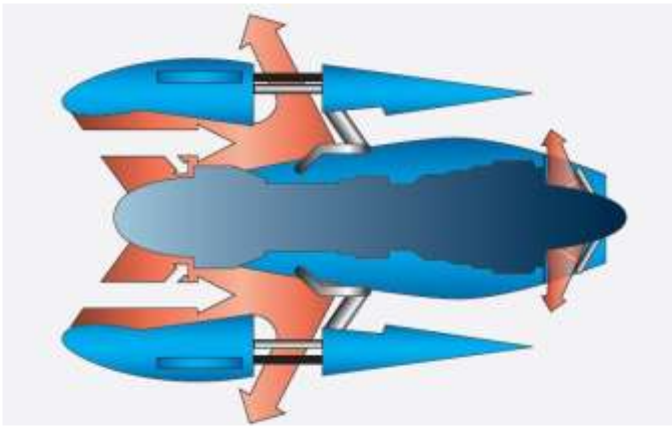
Thrust Levers in Jet Engine

5. FUNCTIONING OF THRUST REVERSERS

Jet powered aircrafts are inclined to experience high amounts of kinetic energy while landing because of excessive weight and speed. Although the wheel brakes are capable of coping up with the speed sometimes there is a necessity for a speed retarding device. This can be satisfied by setting up a device that could produce a reverse thrust. Thrust reversers are the devices that are incorporated in the engine exhaust system which could efficiently reverse the flow of exhaust gases. It is not reversed through 180 degrees. It enables a slight inclination of 45degrees straight ahead of the engine. Generally there are two types of thrust reversers namely **Target reversers** and **Cascade reversers.**



Target type Thrust Reverser



Cascade type Thrust Reverser

Target reversers are just curve-structured doors like components that block the outflow and redirect it forward to achieve reverse thrust. They are also known as **Clamshell reversers.** Cascade reversers are a bit complex structure that specifically reverses the fan air sector alone. The doors which serve as an obstacle to the fan air produce a forward thrust on the fans by means of cascading vanes through some reversing components. Cascade reversers have lesser efficiency than target reversers.

6. EFFICIENCY OF JET ENGINE

When a jet engine is judged by its efficiency it is so obvious that higher efficiency could be achieved when there is higher rpm. The higher rpm of the engine is achieved when the compressor conditions are completely satisfied. For instance if the jet engine is considered to be operated at a normal speed and there arises a requirement for sudden rise in thrust the response time to instantly meet the requirements is very quick. But when the engine is running at low speed if there is a need for immediate full power application it leads to excessive usage of fuel, increase in turbine temperature and even stalling of the compressor. With respect to these calamities there is an obvious dip in the efficiency. For the purpose of avoiding such situations there are certain devices like compressor bleed valve which restrict the engine functioning until the optimum rpm is achieved. The reason for airplanes to operate at a relatively higher rpm during landing and take-off is for the demand of sudden increase in power. As discussed earlier jet engines are efficient when they are at higher altitudes. This is because once jet planes start to fly in the air at higher altitudes, it purely relies on the laws of aerodynamics and fuel consumption is naturally reduced. The economic run of the engine causes the efficiency of the engines to increase. The thrust available at higher altitude is slightly excessive and also supports in maneuvering. Higher altitudes make it easy for maneuvering within the limits of thrust without affecting the stability and control of the flight.

7. MERITS IN SWITCHING TO JET ENGINES

- The mass of the jet engines when being compared with reciprocating engines is relatively less because they are smaller in size although efficient than the latter.
- The absence of a propeller is again one major advantage of this engine with respect to which speed of the engine is not disturbed; higher speed can be achieved anyway.
- They do not necessarily require any kind of lubrication as required in reciprocating engines.
- The engine unit can deal with various ranges of mixture strength without compromising the power requirements.
- The area in the front of the engine is comparatively low when considering reciprocating engines. It reduces the drag and thereby increases the power.
- As discussed earlier due to the presence of continuous ignition, the combustion inside the chamber is continuous and there are no pressure fluctuations.
- From the pilot perspective it is the simplest engine to operate since the thrust levers are the only component which is under manual control and others are automated.
- Due to the absence of reciprocating parts noise and vibrations are drastically reduced.

8. CONCLUSION

Theoretically speaking a jet engine does the work of converting thermal energy by means of combustion and expansion of gases into mechanical energy by means of producing necessary thrust. The absence of propeller effect serves to be a major contribution from the jet engines that is potentially lacking in reciprocating engines. Although pilots need to be accustomed to handle this transition from the reciprocating engines, the phenomenon of operation is very pilot friendly as far as jet engines are considered since thrust levers are the only manually operated component in a jet engine. The compact structure of a jet engine due to the absence of reciprocating parts makes it comparatively weightless and noiseless. Although it is costlier which may be considered as the only drawback, the efficiency of jet engines in higher altitudes is incomparable. This paper serves as a review on the basic operational standards of a jet engine and also supports the aspect of essentially switching over to jet powered aircrafts engines from conventional reciprocating engines.

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