How the F135 Jet Engine Works
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Naval Aviation has developed tremendously over the past several decades. Today the U.S. employs the best equipped and most technologically advanced aircraft in the world. One such example is the F-35 Joint Strike Fighter STOVL variant designed by Lockheed Martin. The feature that makes this fighter jet so unique is its F135 engine created by Pratt & Whitney. The F135 is an aircraft engine that enables the F-35 STOVL fighter jet to fly both horizontally and vertically.

Main Engine Components

The three main components of the F135 that enable both types of airborne flight are the exhaust nozzle, the lift fan, and the roll posts. The exhaust nozzle is used in both vertical and horizontal flight while the lift fan and the roll posts are only utilized during vertical flight. This is because vertical flight is much trickier without rotor blades and the exhaust nozzle is not capable of providing the lift needed all by itself.

Exhaust Nozzle

The exhaust nozzle is the most important part of the F135 engine. Without it, the jet would be rendered useless. The nozzle is a three-bearing swivel module that enables it to be directed horizontally out the back of the plane and vertically towards the ground. During horizontal flight, 100% of the thrust generated is due to the exhaust nozzle. During vertical flight, about 46% of lift generated is used to keep the jet stabilized.

Figure 1 - http://www.airforce-technology.com/features/featurelockheed-martin-f35-pratt-whitney-engine-analysis/
Figure 2 - https://en.wikipedia.org/wiki/Pratt_%26_Whitney_F135

Figure 1

Figure 2
Lift Fan

The lift fan is the second most crucial aspect of the F135 engine. How the fan generates lift is quite simple. A drive shaft connected to the fan is use to turn the fan and force air downwards. It provides approximately the same amount of lift that the exhaust nozzle outputs (46%). Logically this makes sense as if more lift came from the back end of the jet, the nose would point downwards causing it to crash, and if more lift came from the front, the nose would veer upwards causing the jet to stall and crash as well.

Roll Posts

Although the roll posts only provide about 8% of lift need to keep the F-35 jet vertical in flight, they are absolutely necessary as the prevent rolling. Without the nozzles on the end of the posts that force air downwards, the jet would have a difficult time from either rolling clockwise or counterclockwise with the wind. As the name implies, the posts can roll and the nozzles will direct air accordingly to how the pilot wants to fly the plane.

How Air is Used to Power the Engine

Now that you have an understanding of the components of the F-35 engine that make it different from the majority of other engines, it is time to look at how a basic engine works. The flow of air and the processes that take place inside the F-35 engine are based on the same principles that have applied to gas engines for decades. There are two sections that can be looked at separately and it is the cold section and the hot section.

Figures 3&4 - http://www.f135engine.com/public/enginexploration.html?m=1
Cold Section

The reason the first part of the engine is called the cold section is because the air that is flowing through the engine is not heated at this point. On the bottom side of the jet towards the front of the plane are two large air intake chambers. These allow for massive amounts of air to be sucked into the engine and used for the combustion process. However, the air will not provide enough energy and must undergo several steps to become useful for power output. First, let us follow the steps in the cold section.

1. **Intake** – Air is initially drawn into the engine. There is no mechanical device that aids in this process. As the jet begins to take off, air is naturally forced into the engine and as speed increases, so does the air intake. This allows for greater speeds as more power is provided by the engine.

2. **Compression** – The compression stage is vital to the flow process. The F-35 engine utilizes a six-stage high pressure compressor. A compressor is essentially a disc with perpendicular square faces that protrude outwards and spins on a shaft. A six-stage compressor means there are six of these discs placed in series, one right after the other. This design increases the pressure of the air making it more highly combustible for the next stage.

Hot Section

The second stage of the engine is where the air really begins to heat up to well above 1,000 °F. This has to be taken into account when designing the material for the engine, but that will not be discussed in this document. The hot section is where the combustion chambers, turbine, and exhaust are located.

1. **Combustion Chambers** – The combustion chambers is where the jet fuel mixes with the air and burns causing the temperature of the air to increase drastically. The increase in temperature gives the air a lot of kinetic energy which is then utilized in the next stage.

Figure 5 - http://www.airforce-technology.com/features/featurelockheed-martin-f35-pratt-whitney-engine-analysis/
2. **Turbine** – The hot air, loaded with kinetic energy, is then forced into the turbine. The turbine is basically a fan with many blades. The purpose of the turbine is to convert the kinetic energy that the hot air contains into useful mechanical work. This is done by the air turning the shaft of the engine. The shaft is connected to the lift fan and this allows the pilot to utilize the lift fan during vertical flight.

3. **Exhaust** – After the air passes through the turbine, it is accelerated at high speeds and forced out the nozzle. This air at high velocity creates thrust for the jet and enables it to fly vertically.

**Conclusion**

The F-35 is an awesome jet that utilizes an advanced engine design to enable both modes of flight. The air flow throughout the F135 engine is similar to most gas engines. All engines also have some sort of exhaust nozzle but the ability to rotate 90 degrees makes the F135 unique. This combined with the lift fan and rolling posts effectively allow the F-35 to fly both horizontally and vertically.