DOCUMENT

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DOCUMENT TITLE

GAS TURBINE ENGINES (CASA ATPL)

CHAPTER 2 – ENGINE CONFIGURATIONS

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INTRODUCTION

Broadly speaking gas turbine engines can be divided into four main configurations;

- Turbojet,,
- Turbofan or By-pass Fan,
- Free Turbine (Turbo Shaft), and
- Turbo-prop.

By-pass engines may be further type categorised into:

- Low By-pass Turbo Fan,
- High By-pass Turbo Fan ,and
- Contra-Rotating Rear Fan.

TURBOJET ENGINES

Turbo-jet engines consist of a compressor, combustion and turbine section. They function by accelerating a relatively small amount of air to very high speeds, to produce the reactive force required to move the aircraft. It is important to understand that in this type of engine only enough power to drive the compressor and accessories are extracted by the turbine, the remaining exhaust energy provides the thrust.

A single spool axial flow compressor Turbojet is shown on Figure 2-1.

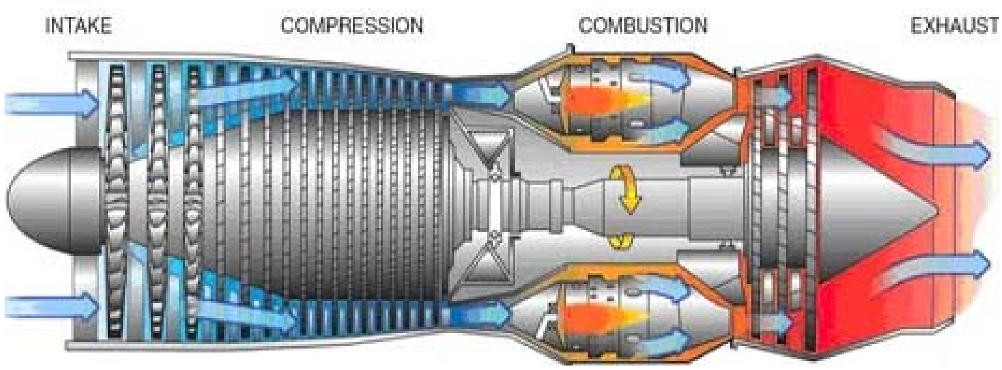


Figure 2-1 Single Spool Axial Flow Turbojet

TURBOFAN OR BY-PASS ENGINES

By-pass engines are so called because some of the air introduced through the inlet does not pass through the hot section (or core) of the engine. The amount of air that by-passes the hot section of the engine defines whether the engine is either a low or a high by-pass engine.

The Turbofan engine can be either high or low by-pass, and consist of a multi blade ducted fan driven by a gas turbine engine. The fan generally has a compression ratio of about 2:1. The high by-pass engine usually has a by-pass ratio of 5:1 and may be as high as 10:1 with the fan providing as much as 80% of the aircraft thrust at low to medium altitudes. The By-pass Ratio is the ratio of the Fan Weight of Airflow to Core Engine Weight of Airflow.

The fan gives the engine roughly the same cruise speed capability as the turbo-jet, coupled with much better short field take-off performance. The engine has much greater fuel economy which is achieved by moving a much larger total volume of air at a lower jet velocity, while burning approximately the same amount of fuel. Refer to Figures 2-2 and 2-3.

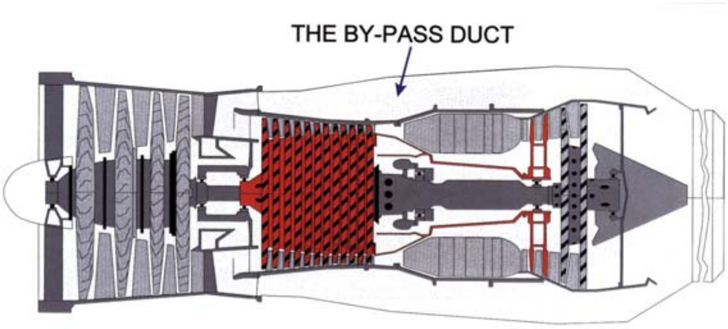


Figure 2-2 Low By-pass Turbofan

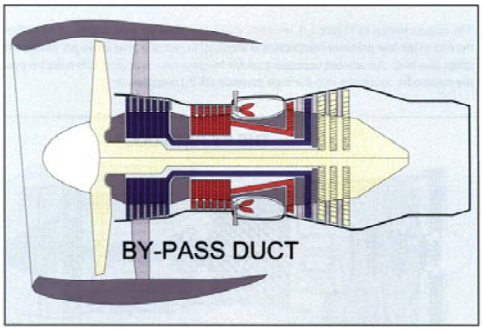


Figure 2-3 High By-pass Turbofan

Contra Rotating Rear Fan

This engine configuration was unveiled in the nineties, and promised turbofan performance with turboprop fuel economy.

This configuration consisted of two pusher, contra rotating propellers, driven by a turboshaft engine. Refer to Figure 2-4.

Although the engine demonstrated extremely low specific fuel consumption, cabin noise levels were a problem, even though the engines were mounted at the rear of the test aircraft. When fuel prices stabilised, the development was terminated.

Figure 2-4 Contra Rotating Rear Fan

FREE TURBINE ENGINES

In a Free Turbine Engine, the (free) turbine is used to drive something other than a compressor. In that turbo-shaft configuration the compressor and turbine (one or two spool) is used to provide the energy to drive a separate turbine .These engines do not produce thrust. Refer to Figure 2-5. There most common use is for driving helicopter rotors, turbo propellers and APUs, while other uses include driving large electrical generators and even main battle tanks (M1A1 Abrams).

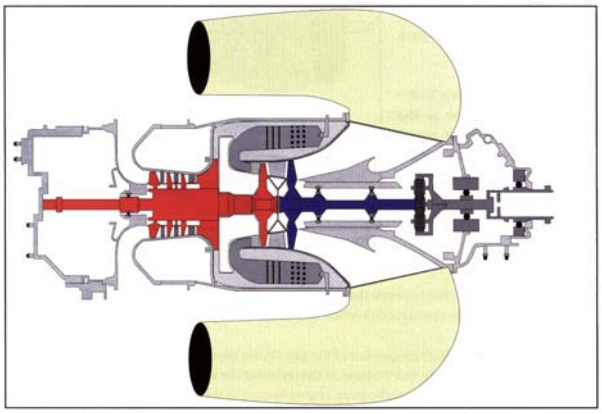


Figure 2-5 Free Turbine Turbo Shaft

TURBO-PROP ENGINES

Turbo-prop engines are in fact a turbo-jet engine driving a propeller. In this configuration the turbine extracts almost all the energy from the gas stream to drive the compressor, accessories, reduction gearbox and the propeller. Any remaining energy is used to provide additional thrust via the exhaust, but this is usually minimal. Refer to Figure 2-6. Turboprop configurations are discussed in more detail in Chapter 10.

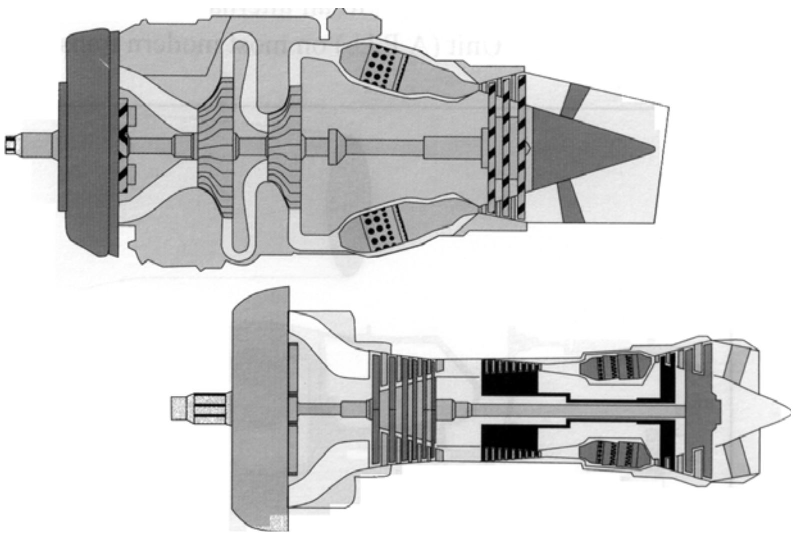
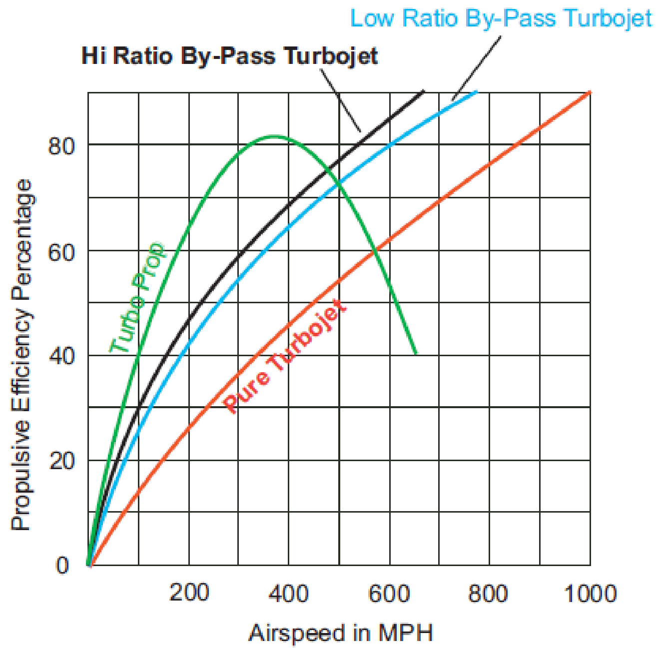


Figure 2-6 Centrifugal and Axial Flow Turboprops

RELATIVE PROPULSIVE EFFICIENCIES

The graph below highlights the propulsive efficiencies and operating envelopes of the different types of jet engines at different aircraft airspeeds.

As highlighted in Chapter 1, the Smaller the Acceleration of the Air Mass the Higher the Propulsive Efficiency.



As Figure 2-7 shows, propellers are extremely efficient up to airspeeds of 400 Knots, but their performance drops off very quickly above that speed. That is due in large to the disturbance of the airflow caused by the speed of the blade tips.

The turbojet is relatively inefficient at low airspeeds due to the lack of ram effect, but efficiency improves as the airspeed increases.

A great deal of energy is wasted with a large velocity transfer to a relatively small mass of air. This has led to the introduction and wide use of the turbo-prop to power aircraft that operate in the medium speed range.

Figure 2-7 Relative Propulsive Efficiencies

The turbofan, (high or low by-pass) offers all the advantages of the propeller and the turbojet in one package. These engines deal with a much larger volume of air and lower jet velocities than the pure turbo-jet giving a propulsive efficiency which is almost as good as the turbo-prop but much better than the turbojet. Figure 2-8 shows the operating envelopes for the different types of power plants.

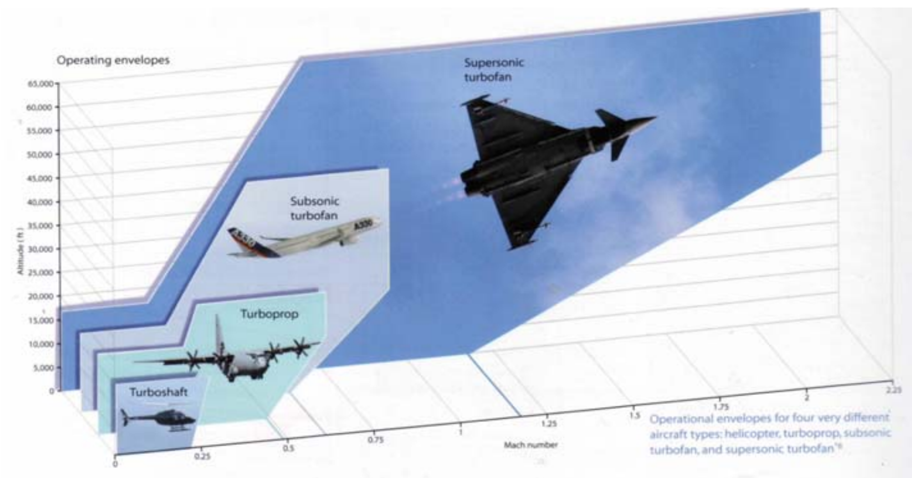


Figure 2-8 Operating Envelopes