Flying
High Performance Singles and Twins

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the scrubbing of oil from the chamber walls. Reduce power, enrich the mixture, and find a landing spot.

Summary and Practical Suggestions

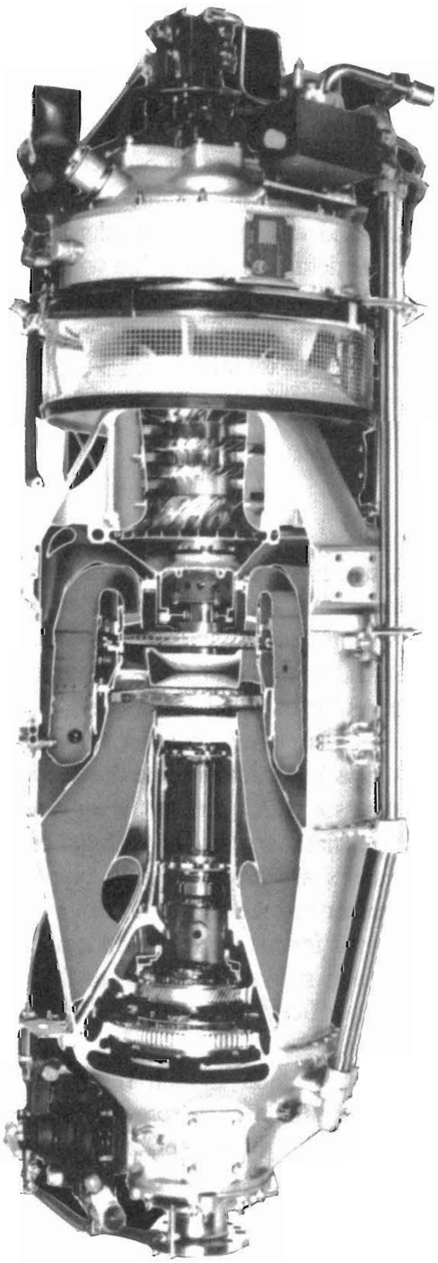
When the airplane climbs with high power and low airspeed, it sometimes needs excess fuel to carry away heat. This may be our main protection from high CHTs or even detonation. But there is little to be gained in other flight situations from pumping unburnable fuel from the tanks, through the cylinders, to the atmosphere. It is a waste of resources and a likely source of plug fouling.

In deciding on how to lean your engine, you must abide by a priority list. First, you must keep other engine parameters, mainly CHT and TIT, within limits. Second, if your airplane manufacturer lists leaning instructions, you should follow them. Third, if the manufacturer's instructions are vague or nonexistent, follow the engine manufacturer's guidelines. Finally, if your engine is approved for a wide array of EGT values, forget your old habits and do some experimenting to find what works best. You may be pleasantly surprised.

Sources

Graphic Engine Monitor Pilot's Guide, Insight Instrument Co. (Buffalo, 1987).

Obert, Edward F., *Internal Combustion Engines*, 3rd ed., International Textbook Co. (Scranton, 1968).



The PT6A. Photo courtesy of Pratt & Whitney Canada.

5. Turbine Engines

When you graduate to turbine-powered airplanes, it is time to take a specialized course for a week or so to study the airplane's systems, performance, procedures, and so on. A large part of such a course will deal with the powerplant. You will cover the engine layout, systems, and limitations as well as normal and emergency procedures. This chapter cannot possibly substitute for the detailed training you will need. My object here is to give you a brief introduction to the general features of gas turbine engines, so you will know a few basics and at least become an intelligent beginner or right-seat observer. What we will do is take a look at the Pratt & Whitney Canada PT6A turboprop, which is the most prevalent engine of this type.

The Layout of the PT6A

The photo on the previous page shows a cutaway view of one of the smaller versions of the PT6A. Figure 1 shows a highly simplified line drawing of the PT6A. Air enters near the rear of the engine and is directed to a three-stage axial compressor. An axial compressor is like a house fan; it moves air parallel to its axis of rotation. It is called "three-stage" simply because there are three of these compressors in a row. (Larger versions of the PT6A have four axial compressor stages.) Air leaving the third axial compressor is routed to a centrifugal compressor which pushes the air outward and then forward toward the combustion chamber. The centrifugal compressor and three (or four) axial compressors are mounted on a common shaft that extends forward to the compressor turbine and aft to drive the accessories. The engine employs a compressor for the same reason a piston engine has a turbocharger and a compression stroke, that is, to enable the engine to generate more power with greater efficiency.

The combustion chamber is a perforated annular ring-shaped steel shell surrounding the central axis of the engine. Air from the compressor section enters the combustion chamber through the perforations, and it is then mixed with fuel, which is sprayed into the chamber at a rate dictated by the fuel control unit. There are two ignitor plugs in the combustion chamber. These are used for starting and to insure continued combustion during operations in heavy precipitation.

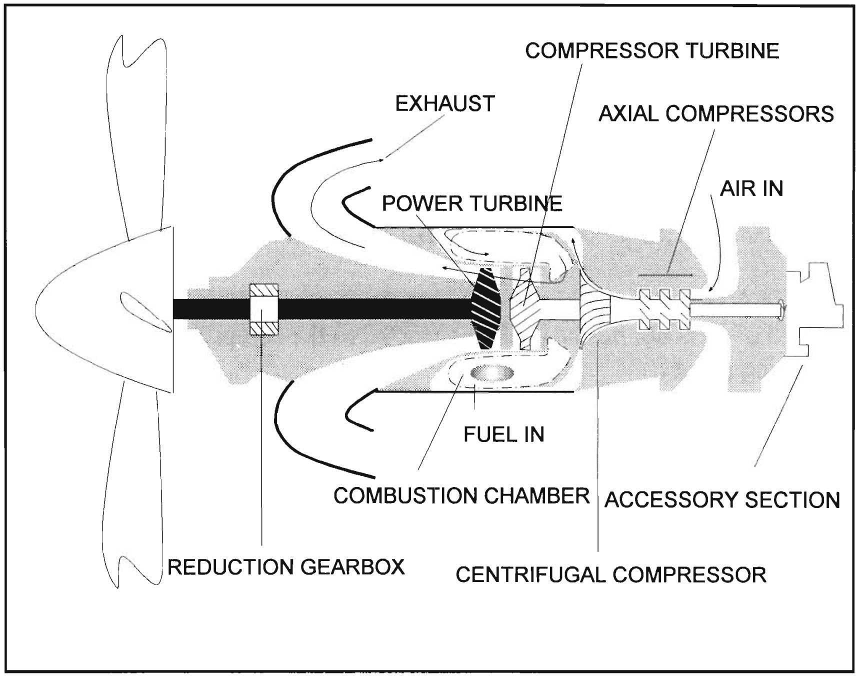


Figure 1. Layout of the Pratt & Whitney Canada PT6A.

The temperature in the combustion chamber can be in the neighborhood of 2000° C, but under normal conditions the flame does not touch the walls of the combustion chamber due to the high flow of air into the chamber. About two-thirds of the air passing around and through the combustion chamber is never involved in combustion; it is there to keep temperatures acceptable. Without this excess air, the combustion chamber and turbines would deform from the heat.

The hot, high-velocity, high-pressure burned gases now are forced to make another turn as they are routed forward past guide vanes to the compressor turbine. The flow of these hot gases forces the compressor turbine to spin, just as the wind turns a windmill. The compressor turbine is connected by a shaft to the centrifugal and three (or four) axial compressors. The flow of burned gases past the compressor turbine provides the energy that drives the compressor section.

Coming out of the compressor turbine the gases are routed through guide vanes and then over one or two power turbines (there are two in the larger engines), forcing them to spin opposite the direction of the compressor turbine. The hot gases then pass out through the exhaust. A shaft coming forward from the power turbine connects to a 15-to-1 reduction gearbox. The reduction gearbox reduces RPM from about 33,000 to something closer to the 2000 that the propeller can use effectively.

The PT6A is a "free turbine," meaning the power turbine (and everything forward of it) is not mechanically connected to the compressor turbine (and everything aft of it).

Engine Controls

The PT6A is controlled by a power lever, a propeller control lever, and a fuel condition lever. We will look briefly at each.

Pushing the power lever forward from its idle detent sends more fuel to the engine, increasing engine torque and "Ng," which is the abbreviation for the "gas generator" RPM. (On a turboprop engine, the term "gas generator" refers to the compressor, combustion, and compressor turbine sections.) A flyweight-type Ng governor senses the position of the power lever and the gas generator RPM. Pushing the power lever forward resets the governor to maintain a higher Ng speed. Lifting the power lever up over a gate as you pull it aft below idle rotates the prop blades past their usual fine pitch, high RPM, stop into the beta and reverse mode. As the power lever is pulled further back, more fuel is delivered to the engine with the blades in their reverse thrust position. This creates more reverse thrust.

The propeller RPM is controlled by a conventional constant-speed governing unit, which you control the same way you would in any airplane with a constant-speed propeller. The position of the prop lever sets the RPM between full feather and max prop RPM.

The fuel condition lever has three positions. Pulled all the way aft, it cuts off fuel to the engine. Set in the low idle or ground idle position with the power lever in the idle detent, it provides fuel for starting and for engine idling at Ng values of about 51 percent on the smaller PT6A and 56 percent on the larger versions. With the condition lever in high idle and the power lever at its idle stop, Ng increases to some preset value of 60 to 70 percent, as determined by the airframe manufacturer. So other than serving to cut fuel off, the condition lever essentially resets the idle stop for the power lever.

Engine Instruments

Figure 2 shows the four basic engine instruments. The torque delivered to the propeller is sensed by a torque sensor located in the reduction gearbox. As we learned in the chapter on normally aspirated engines, the shaft (SHP) or brake (BHP) horsepower of the engine is equal to torque (in foot-pounds) times prop RPM divided by 5255. So as far as the generation of SHP is concerned, torque is directly "exchangeable" for RPM. Or viewing things

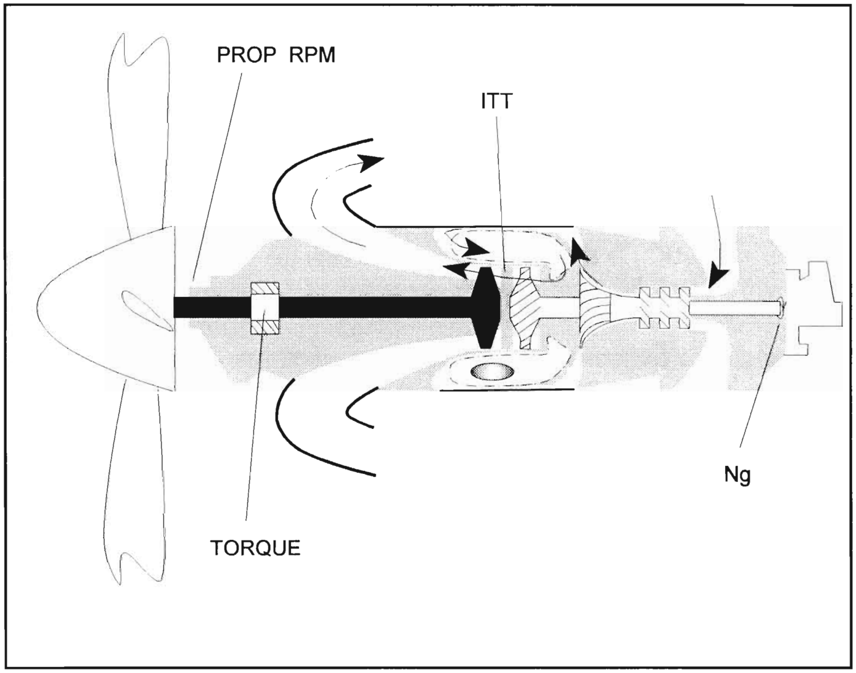


Figure 2. Engine sensors.

a little differently, with RPM fixed, power is directly proportional to torque, and this makes the torque indicator your primary power reference. You will see turbine engine power output stated in terms of shaft horsepower (SHP) and equivalent shaft horsepower (ESHP). The shaft horsepower comes