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Editorial

Turbofans and Turbojets with a Low-Bypass System

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EDITORIAL

A turbofan, often known as a fanjet, is a type of air breathing jet engine that is commonly employed in aircraft propulsion. The term "turbofan" is a combination of the words "turbine" and "fan": the turbo component refers to a gas turbine engine that generates mechanical energy through combustion, and the fan portion refers to a ducted fan that uses the mechanical energy generated by the gas turbine to force air rearwards. The bypass ratio is the ratio of the mass-flow of air bypassing the engine core to the mass-flow of air flowing through the core.

The engine generates thrust by combining these two components; engines that utilise more jet thrust than fan thrust are known as low-bypass turbofans, while those that use significantly more fan thrust than jet thrust are known as high-bypass turbofans. The majority of commercial aviation jet engines in use today are high-bypass, while the majority of modern military fighter engines are low-bypass. Modern turbofans have either a huge single-stage fan or a smaller multi-stage fan. An early design combined a low-pressure turbine and a fan into a single rear-mounted unit.

Turbofans were developed to avoid the drawback of turbojets being inefficient for subsonic flight. To improve the efficiency of a turbojet, the logical method would be to raise the burner temperature, which would result in improved Carnot efficiency and the use of larger compressors and nozzles. While this increases thrust slightly, the exhaust flow exits the engine at a higher velocity, which, at subsonic flying speeds, takes the majority of the increased energy with it, wasting fuel. Instead, a turbojet is employed to drive a ducted fan, with both contributing to thrust, resulting in a turbofan. In contrast, all of the air taken in by a turbojet is sent via the turbine.

BPR (Bypass Ratio) is commonly used to characterise turbofan engines, and it, along with overall pressure ratio, turbine inlet temperature, and fan pressure ratio, is a significant design parameter. Furthermore, BPR is quoted for turboprop and unducted fan installations because their great propulsive efficiency gives them the overall efficiency of very high bypass turbofans. This enables them to be displayed alongside turbofans on graphs that demonstrate trends of decreasing Specific Fuel Consumption (SFC) with rising BPR. BPR can also be estimated for lift fan systems in which the fan airflow is distant from the engine and does not pass through the engine core. Bypass generally relates to transferring gas power from a gas turbine to a bypass stream of air to reduce the amount of energy and jet noise.

Alternatively, an afterburning engine may be required where the only necessity for bypass is to produce cooling air. This lowers the limit for BPR, and these engines have been dubbed "leaky" or "continuous bleed turbojets." The high temperature and high pressure exhaust gas in a turbojet (zero-bypass) engine is accelerated by expansion through a propelling nozzle and creates all of the thrust. The turbine's mechanical power is completely absorbed by the compressor. Extra turbines operate a ducted fan that accelerates air backward from the front of the engine in a bypass design. The ducted fan and nozzle create the majority of the thrust in a high-bypass design. In theory, turbofans and turboprops are similar in that they both use extra gear to transfer some of the gas turbine's gas power to a bypass stream, leaving less for the hot nozzle to convert to kinetic energy.

A multi-stage fan is typically used in a high-specific-thrust/low-bypass-ratio turbofan, producing a relatively high pressure ratio and, as a result, a high (mixed or cold) exhaust velocity. The core airflow must be large enough to provide adequate core power to run the fan. Raising the High-Pressure (HP) turbine rotor input temperature results in a smaller core flow/higher bypass ratio cycle. With suitable efficiencies and duct loss for the extra components, the resulting turbofan would most likely operate at a greater nozzle pressure ratio than the turbojet, but at a lower exhaust temperature to retain net thrust. Because the temperature rise across the entire engine (intake to nozzle) would be lower, the (dry power) fuel flow would be reduced as well, resulting in lower Specific Fuel Consumption (SFC).

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