AVIATION

What is a “high-bypass geared turbofan,” and why is it so much more efficient?

Asked 5 years, 4 months ago Active 5 years, 4 months ago Viewed 5k times

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According to the article Bombardier’s CSeries Gamble Is Facing Longer Odds, this new plane from Bombardier uses a new engine technology that will improve efficiency over its rival 737 series and A320 series airplanes, to the point where it will be able to complete on a seat-mile efficiency basis with larger airplanes, enabling it to bypass hubs:

> The linchpin for the CSeries was a new concept for engines developed by Pratt & Whitney, known as a high bypass geared turbofan. The new engine design promised exceptional fuel savings of up to 20 percent and unusually low noise levels.

What's the theory behind this new engine, and what are the underlying numbers that make it competitive with larger airplanes?

airline-operations boeing-737 airbus-a320 turbine bombardier

edited Jan 10 '15 at 0:09
DeltaLima
64.2k 7 205 286

asked Jan 9 '15 at 16:24
rbp
15.7k 1 53 99

2 I think that the fan can rotate at a different speed then the compressors – ratchet freak Jan 9 '15 at 16:25

1 Answer

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The fan section of a turbofan engine is driven by the low pressure (LP) spool. This means that it is connected to two parts of the engine:

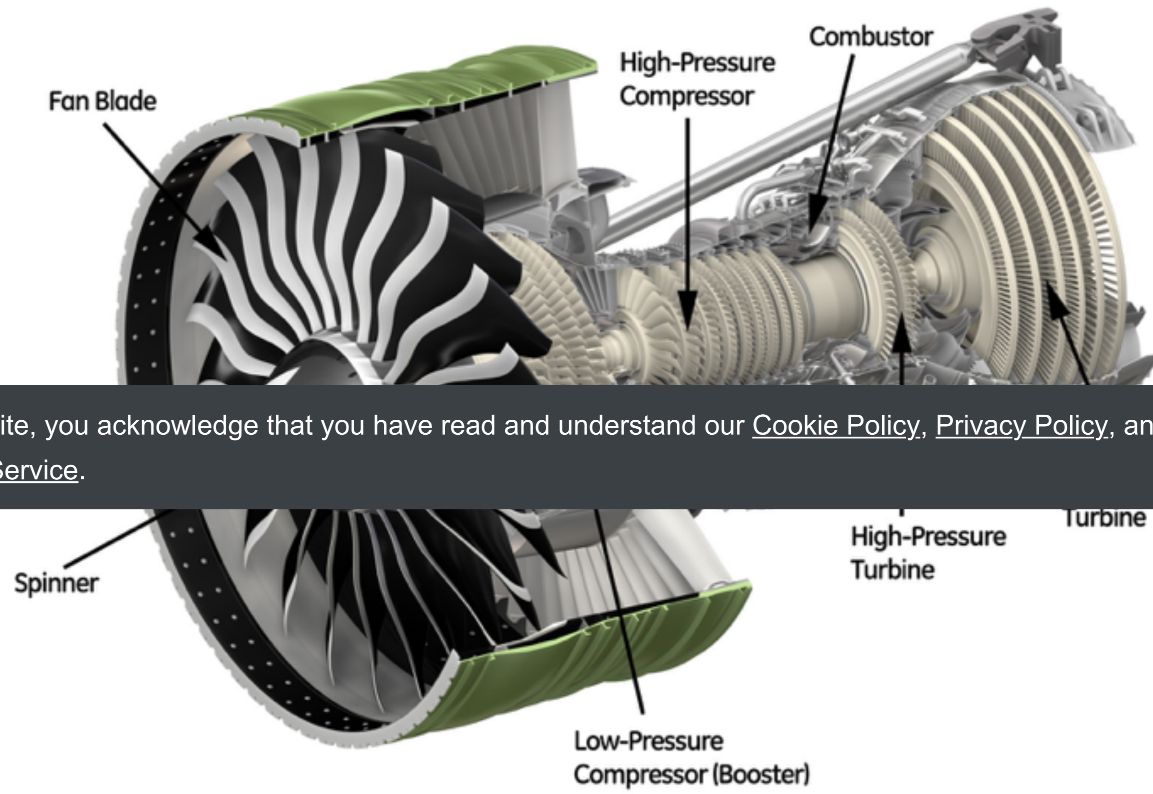
- The LP compressor, which must compress the air before it enters the high pressure (HP) compressor
- The LP turbine, which must receive the air after it exits the HP turbine

The problem is that the HP section is efficient at high RPM. But the fan will reach aerodynamic limits as the fan tips pass supersonic speed. Fan blades are also harder to contain in the event of a failure as they spin faster. So to accommodate the fan, the LP section has to spin at a slower speed, which makes it harder to match with the high RPM HP section.

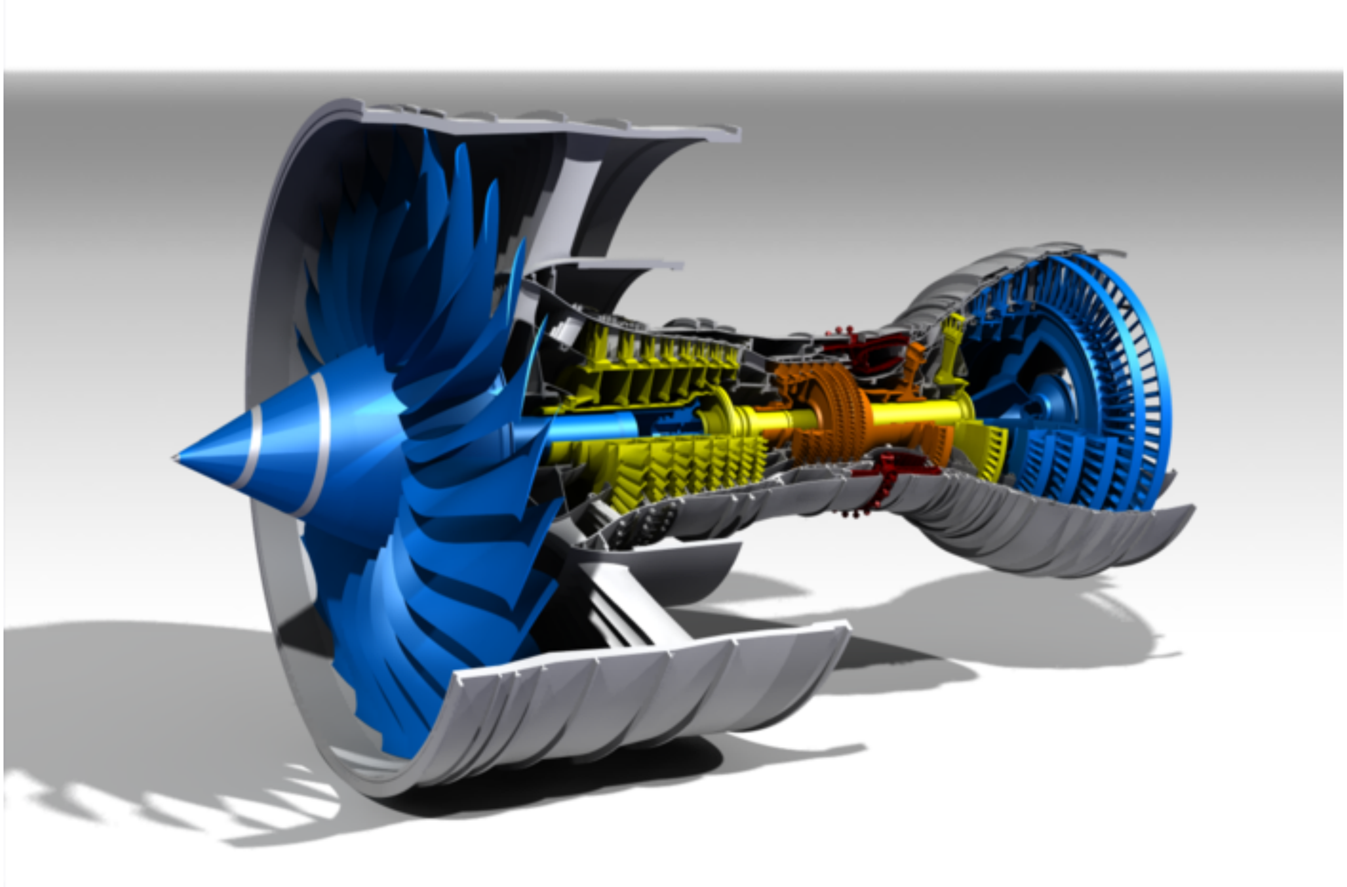
There is also a limitation on air flow. The fan must be able to move a maximum amount of air, which is takeoff power at sea level. But it must also be able to function efficiently at cruise level, where the flow is faster but much less dense.

Engine companies use different strategies to deal with these limitations.

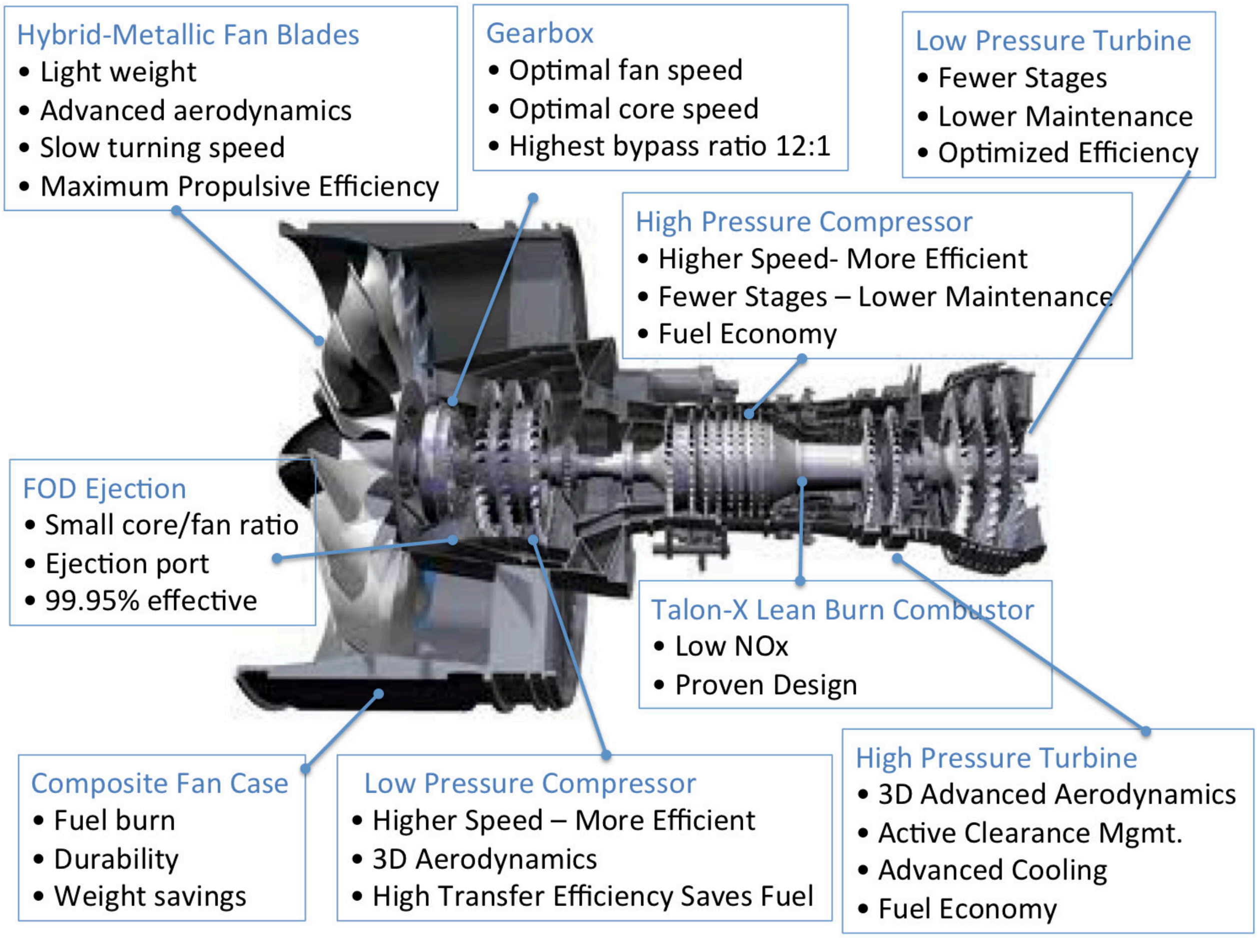
GE mainly makes the LP sections larger in diameter. This allows the blades to have a high velocity at lower RPM. This this requires the air flow to change direction more rapidly.



Rolls Royce has created a 3 spool design, which allows each section to spin at a more optimal RPM. This adds complexity to the design.



Pratt and Whitney is going with the geared fan approach. Similar to turboprops, there is a gearbox to allow the fan to spin at a lower speed than the engine spool that is driving it.



This allows the turbine spool to operate at a more optimal RPM while still allowing the fan to spin more slowly. A slower fan can be larger, allowing for a higher bypass ratio.

A high bypass ratio allows a turbofan engine to drive more air (produce more thrust) for less air going through the core (burn less fuel). Modern large aircraft have engines like the GE90 on the 777 (9:1 bypass), with the latest engines on the 787 going even higher with the GEnx (9.6:1 bypass), and Trent 1000 (10.8:1). Smaller aircraft like the 737 and A320 currently use engines like the CFM56 (5.5:1), with the new LEAP going higher (9:1 or 11:1). The PW1000G goes even higher (up to 12:1).

edited Jan 9 '15 at 19:10 answered Jan 9 '15 at 17:56

fooot ♦
66.9k 18 210 378

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which is the engine on the CSeries? the PW1000G? – rbp Jan 9 '15 at 17:58

@rbp Yeah, PW1500G – fooot ♦ Jan 9 '15 at 18:26

6 The tips of modern fan blades run at Mach 1.5. There is no aerodynamic limit at Mach 1, but speed increases come with higher penalties. – Peter Kämpf Jan 9 '15 at 18:46