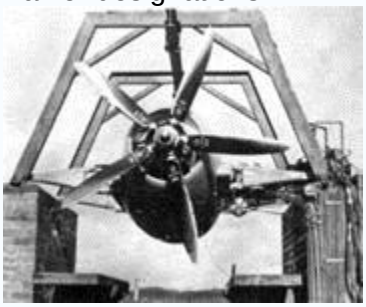
Rolls-Royce Trent

Rolls-Royce Trent 900 on A380 prototype

Rolls Royce Trent is a family of high-bypass turbofan engines manufactured by Rolls-Royce. All are developments of the famous RB211 with thrust ratings spanning between 53,000 to 95,000 lb_f (236 to 423 kN). The name has also been used for a number of previous designs.

Earlier designations



The first *Trent* - a Rolls-Royce RB.50 Trent on a test rig at Hucknall, in March 1945

"Trent" was the name originally given by Rolls-Royce to the world's first turboprop engine (right). It was based on a concept provided by Sir Frank Whittle and derived by mating a five-bladed propeller driven through a reduction gearbox onto the company's Derwent II turbojet. It first flew on an experimental Gloster Meteor aircraft in the middle 1940s.

The designation was reused again in the 1960s for the RB203 bypass turbofan which was designed to replace the Spey. It was the first three-spool engine, forerunner of the RB211 series. It was rated at 9980 lb_f (44.4 kN).

Present designation

The current Trent is the development of the three-shaft RB211 family of engines. By 1987, a variant of the RB211, the RB211-524L, had been developed to such an extent that it bore little resemblance to the original RB211, other than the three-shaft layout. Rolls-Royce decided that the 524L would be the basis of a new engine family, and so the newest Trent was born. Rolls-Royce had started naming their engines after British rivers in 1942—a practice which was revived for the Trent after a 30-year gap.

The Trent's advanced layout provides lighter weight and better performance compared to the original RB211 and other comparable competing engines. It features the wide-chord fan and single crystal

high-pressure turbine blades inherited from later generations of the RB211, but with improved performance and durability.

The core turbomachinery is brand new, giving better performance, noise and pollution levels. In fact, it was seen fit to be retrofitted to the RB211-524G/HT for improved performance compared to the original 524G and 524H. The Trent's advanced layout allows it to be fully scalable to the widest range of thrust of any current generation large turbofans.

Airbus gives all Rolls-Royce engined planes the designator "4"; eg. A330-342 or A380-841.

History

By the early 1990's, Rolls-Royce RB211 had 15 to 20 percent market share of the big commercial turbofans; however, GE and Pratt and Whitney were still way out in front. In the late 1980's the huge growth of ETOPS capable airliner twinjets led to demands for higher thrust rated turbofans. The option to Rolls-Royce was either to update the RB211 or risk exiting the big turbofan business; the result was, of course, that the RB211 was redeveloped into the Trent. The new Trent family spawned derivatives capable of powering a wide range of airliners.

The initial variant, Trent 600, was to power the McDonnell Douglas MD-11 with British Caledonian as its launch customer. The subsequent takeover of British Caledonian by British Airways led to its cancellation, and later as the trijet itself suffered poor sales (which one of the reasons is due to the delay of the Trent 600) the Trent 600 was put on ice. Then with the launch of Airbus A330, the Trent 700 was launched with initial customer, Cathay Pacific in March 1995. The Trent 700 was selected by many A330 customers and later went on to become the primary engine for the A330.

The Trent 800 for the Boeing 777 was also launched by Cathay Pacific. However, initially, Rolls-Royce had difficulty selling the engine. British Airways, traditionally a Rolls-Royce customer, submitted a big order for the competing General Electric GE90 engine. The breakthrough came when the company won orders from Singapore Airlines, previously a staunch Pratt & Whitney customer, for its 34 Boeing 777s; this was when sales really took off and large North American orders from American Airlines and Delta Air Lines for their 777 fleets soon followed. Since then the Trent has risen to become the market leader for the 777 and has established a reputation for being a very reliable engine with good after-sales support; British Airways returned to Rolls-Royce for its second batch of 777s.

Soon after in 1997, the Trent 500 was chosen to power the long-range quad-engined Airbus A340-500/-600 family. It entered service with Virgin Atlantic Airways' A340-600 in mid-2002 and with Air Canada's ultra-long range A340-500 in 2003. This was followed by the 70,000 to 80,000 pound (310 to 360 kN) thrust Trent 900, which was the launch engine for the Airbus A380.

The latest in the family is the Trent 1000, which was launched on the back of All Nippon Airways' order for 50 Boeing 787s. Trent's market share has wildly exceeded early Rolls-Royce market projections and has currently garnered more sales than its competitors (GE and Pratt & Whitney) combined, capturing more than 50% of the market for 2004.

Trent's excellent design has also been adapted for marine and industrial applications. The huge revenue generated from sales has also propelled Rolls-Royce's market position to the second biggest engine manufacturer in the world.

Triple-spool advantages

The Rolls-Royce RB211 and Trent use a triple-spool design rather than the more common twin-spool design. Although inherently more complex than a typical twin-spool design, the superiority of this design shows at higher thrust ratings by the total improvement achieved. Excellent development progress from the original RB211-22 to the current Trents has turned Rolls-Royce's higher thrust turbofans into performance leaders in their respective thrust rating classes, which translates into a market leadership figure of excess of 50% of all total widebody orders in 2004.

As thrust rating increases, the high-pressure compressor increases in length resulting in a more complex airflow which increases the probability of airflow instability and compressor stall. Twin-spool engines require complex airflow control devices to prevent this but the triple-spool design gets around this problem by splitting the high pressure compressor into two, thereby increasing the total number of engine compressors to three. Each compressor is now allowed to rotate at its own optimum speed, making the engine's airflow very stable over a wide range of spool speeds.

A triple-spool design features a higher compression ratio as compared to a twin-spool design making it generally shorter and lighter. The Trent, for example, is lighter than its General Electric GE90 equivalent. A lower individual spool rotation speed leads to a reduced parts count resulting in longer life and reduced maintenance costs.

Most importantly, the triple-spool design allows design flexibility by simply resizing the compressors and turbines to accommodate different thrust ratings. The Trent's broad spread of thrust ratings spans 56,000 to 107,000 lbf (249 to 476 kN) and may be increased to 110,000 lbf (489 kN). By comparison, Pratt & Whitney's PW4000 series engines have a range of 56,000 to 90,000 lb_f (249 to 400 kN), GE's CF6-80 a range of 56,000 to 68,000 lb_f (249 to 302 kN) and GE90 a range of 84,000 to 115,000 lb_f (374 to 512 kN). This flexibility allowed Rolls-Royce to offer engines earlier than others for newer aircraft such as the Boeing's Next Generation 747 and 787 and Airbus' A340-500/600, A350 and A380.

Variants

Trent 500 Series

The Trent 500 family was designed to power the Airbus A340-500 and A340-600. It comes in 2 thrust ratings: 53,000 and 56,000 lb_f (236 to 249 kN). The Trent 500 features a Trent 700 wide-chord fan together with a core scaled from the Trent 800. The Trent 500 series is the most reliable member of the Trent family. It features the lowest maintenance costs for its ultra-long range class application.

Trent 600 Series

The Trent 600 family is designed to power future Boeing 747 aircraft developments. It is actually a refinement of the original RB211-524L. According to Rolls Royce, it performs better than any current 747 engine. However, with the launch of the 747-8, Boeing has chosen to go with GE engines destined to power the upcoming 787.

Trent 700 Series

The Trent 700 family was designed to power the Airbus A330. It features a fan with a diameter of 2.47 m and comes in 2 thrust ratings, 67,500 and 71,000 lb_f (300 to 316 kN). It first entered service on Cathay Pacific A330s in March, 1995.

Trent 800 Series

The Trent 800 family is designed to power the Boeing 777. It powers the 777-200, 777-200ER, and 777-300 variants. It is available with thrust ratings spanning 75,000 to 95,000 lb_f (334 to 423 kN).

The hollow titanium wide-chord fan is 2.89 m in diameter. The engine is one of the lightest in its class; a Trent-powered Boeing 777 weighs up to 3.6 metric tons less than General Electric and Pratt & Whitney-powered versions.

The Trent 800 was the first engine to be certified for ETOPS (Extended range over-water operations by twin engine aircraft) at entry into service. Since that time it has become a class leader for reliability, regularly returning a basic engine dispatch reliability of 99.9% which was a factor in securing 80% of installations on 777s since the start of 1997 and over 2 million flying hours since 1996.

Trent 8104

Originally designed for the 777-200LR and 777-300ER (both part of the 777X project), this engine comes in two thrust ratings, 104,000 and 114,000 lb_f (463 to 507 kN), and has been tested up to 117,000 lb_f (520 kN).

Rolls-Royce offered the 8104 to Boeing earlier than other manufacturers. Boeing had a requirement that the participating engine developer assume a risk-sharing role on the overall 777X project. Rolls-Royce was unwilling to do so, and thus Boeing chose advanced developments of the GE90, the GE90-110B and GE90-115B. This relegated the 8104 to the role of demonstrator engine. It featured swept-back fan blades and a host of new technologies such as contra-rotating spools.

Trent 900 Series

The Trent 900 family is designed to power the Airbus A380, for which it is the launch engine. It comes in two thrust ratings, 70,000 and 76,000 lb_f (311 and 338 kN) but is capable of achieving 84,000 lb_f (374 kN). It features a significant amount of technology inherited from the 8104 demonstrator including its 2.95 m diameter swept-back fan. It is also the first member of the Trent family to feature a contra-rotating HP spool and uses the core of the very reliable Trent 500. It is the only A380 engine that can be transported on a Boeing 747 freighter.

Engine controls is provided by Hamilton Sundstrand, a United Technologies (UTC) company. UTC is also the parent company of Pratt & Whitney, who, with GE Aircraft Engines, is partnering to produce the Engine Alliance GP7200, the other engine available for the A380. This kind of cooperation among competitors is prevalent in the aircraft market as it provides for risk sharing among them and diversity in source countries, a significant factor in an airlines' choice of airframe and powerplant.

The Trent 900 made its maiden flight on May 17, 2004 on Airbus' A340-300 testbed, replacing the port inner CFM56-5 and dwarfing the remaining engines. A380 customers which have selected the

Trent include Virgin Atlantic, Qantas, Singapore Airlines (the first to fly the Trent 900 powered A380), Lufthansa, Malaysia Airlines, Etihad Airways and China Southern Airlines.

Trent 1000 Series

On April 6, 2004 Boeing announced that it had selected two engine partners for the 787, Rolls-Royce and General Electric. Initially, Boeing toyed with the idea of sole sourcing the powerplant for the 787, with GE being the most likely candidate. However potential customers demanded choices and Boeing relented. For the first time in commercial aviation, both engine types will have a standard interface with the aircraft, allowing any 787 to be fitted with either a GE or Rolls-Royce engine at any time. Engine interchangeability makes the 787 a far more flexible asset to airlines, allowing them to change from one manufacturer's engine to the other's in light of any future engine developments which conform more closely to their operating profile. The engine market for the 787 is estimated to be $40 billion USD over the next 25 years.

The Trent 1000 (as well as GE's GEnx) are both evolutionary derivatives of existing designs, whereas the Pratt & Whitney engine was to be an all-new design.

The technology found in the Trent 8104 demonstrator is used extensively. The Trent 1000 is a bleedless design, with power take-off from the intermediate-pressure spool instead of the high-pressure spool found in other members of the Trent family, to fulfill the Boeing requirements of a "more-electric" engine. A 112-inch diameter swept-back fan, with a smaller diameter hub to help maximize airflow, was specified. Bypass ratio has been increased over previous variants by suitable adjustments to the core flow. Contra-rotating the IP and HP spools improves IP turbine efficiency, while use of more monolithic parts reduces the parts count for lower maintenance costs. A tiled combustor is featured.

Leading particulars for the Trent 1000 are as follows:

1. Bypass ratio: 10-11
2. Overall pressure ratio (Top-of-Climb) 52:1
3. Take-off thrust: 53000 - 75000lbf (flat-rated to ISA+15C)
4. Airflow: 2400 - 2670lb/s
5. Fan diameter: 112in
6. Length: 160in
7. Weight: 11924lb
8. Stages: 1LPC,8IPC,6HPC,1HPT,1IPT,6LPT
9. Certification:2007
10. EIS:2008

In June 2004, the first public engine selection was made by Air New Zealand, who chose Trent for its two firm orders. The airline has options for 16 more 787s. In the most significant 787 order, that of Japan's All Nippon Airways, Rolls-Royce was selected as the engine supplier on October 13, 2004. The deal is valued at $1Bn (£560m). As of January 2006, GE now has a lead over Rolls-Royce by 26 orders.

The first run of the Trent 1000 was, as scheduled, on the 14 February 2006.

Trent 1500 Series

A Trent 500 replacement engine, known unofficially as the Trent 1500, has been proposed for the Airbus A340-500/600, to help the aircraft compete with the Boeing 777-200LR/300ER.

The Trent 1500 would retain the 97.4in fan diameter of the current Trent 500 engine, as well as the nacelle, but incorporate the smaller, more advanced, Trent 1000/1700 gas generator and LP turbine, suitably modified.

Trent 1700 Series

Rolls-Royce offered a variant of the Trent 1000, dubbed Trent 1700, optimised for Airbus's A350 beginning on October 6, 2005, The Trent 1700 will be largely the same as the Trent 1000, though with more power (75,000 lb_f). Unlike the Trent 1000, the Trent 1700 will be a conventional bleed-air engine.[1] Kawasaki has partnered with Rolls-Royce to develop this engine.

MT30

The Marine Trent 30 is a derivative of the Trent 800, (with a Trent 500 gearbox fitted), producing 30 megawatts (MW) for maritime applications. The current version is a turboshaft engine, producing 36 MW, using the Trent 800 core to drive a power turbine which takes power to an electrical generator or to mechanical drives such as waterjets or propellers.

References

1. ↑ "Rolls-Royce to develop Trent 1700 for A350", David Kaminski-Morrow, *Flight International*, October 6, 2005.

External links

- Rolls-Royce plc
  - Trent 500 series
  - Trent 700 series
  - Trent 800 series
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