The Vinci engine on track again

Volvo Aero developes and manufactures the turbines

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Model of the Vinci Engine.

Photo: Nordicspace

When ESA gave the green light for further development of the Vinci engine last autumn, they also gave the go-ahead for further development of the turbines the Swedish company Volvo Aero is responsible for, and the work is now evolved around engine testing.

Vinci is a cryogenic, liquid hydrogen (LH2) and liquid oxygen (LOX), expander cycle engine with the two turbines arranged in series. Volvo Aero is responsible for the development and manufacturing of the turbines for both turbo pumps, including development of test facilities, materials testing in hydrogen atmosphere, aerodynamic design, and mechanical design along with the development of advanced measuring techniques. Volvo Aero has been subcontracted by Snecma Moteurs, France, for the LH2 turbine and by Fiat Avio, Italy, for the LOX turbine.

The development of the turbine is supported by regular testing from the very beginning, starting with the testing of a demonstration turbine to address the rotor tip clearance losses and influence of different blade layouts, followed by performance demonstrations in air using real hardware for two different clearances. In the subsequent turbo pump testing the turbine is tested under real hydrogen conditions, however not fully under engine conditions

The Vinci engine is a cryogenic upper stage 180 kN thrust engine which provides multiple firing capability and therefore has the potential for application on various future launcher upper stages as well as orbital spacecrafts. The Vinci programme is managed by the French national space agency CNES, by delegation of ESA. In May 2005 the first successful engine test with ignited combustion chamber was reported, and that marked the start of the last steps in the verification phase in the present development programme.

The turbine design has been challenging from the beginning, optimizing demands on low production cost and necessary performance requirements. The basic turbine features are small overall size, moderate mass flow, low volume flow, medium to low pressure ratio, limit weight and low cost.

The programme was cut off budgets in 2003 to give financial room in order to bring Ariane 5 ECA in service real quickly again after the launch failure in December 2002. The Vinci engine would permit the current Ariane 5 ECA rocket to boost its payload capacity to 12 000 kilograms to a Geostationary Transfer Orbit (GTO), an increasing of about 2000 kilograms. The Vinci engine will have a thrust more than twice of the HM7B, now in use in Ariane 5 ECA. However, the largest improvement is the possibilities for re-starting, a possibility that will increase the utilisation possibilities essentially.

Two valves control propellants supply the combustion chamber, while two other turbine bypass valves regulate turbo-pump power, which in turn controls mixture ratio and thrust. One particular feature of this engine is that it is able to re-start in flight, using electric igniters.

The Vinci engine uses an expander cycle in which hydrogen fuel cools the thrust chamber before driving first the hydrogen turbo pump and then the oxygen pump. The liquid hydrogen pump is powered by a single stage axial subsonic high performance LH2 turbine. The liquid oxygen pump is powered by a single-stage axial subsonic high-performance LOX turbine. The Vinci turbines constitute a large step towards reduced cost thanks to innovative manufacturing techniques, including brazed-stat or manufacturing, and traditional blade manufacturing using blisk technology instead of individual blades.

Parts for Vinci turbines.

Photo: Volvo Aero

Ariane 5 ECA at the launch pad. Vinci will be the second stage and contributing to increase the capasity to 12 tonns to the geostationary Transfer Orbit (GTO).

Photo: ESA

The characteristics for the Vinci engine is a thrust in vacuum at 180 kN, it will be re-ignitable with a chamber pressure at 63 bar, have a specific impulse of 465 s and operate over a time at 700 s.

Those demands provide the following characteristics for the Vinci turbines.

	LH2 turbine	LOX turbine
Power rating	2500 kW	390 kW
Speed	91,000 rpm	18,800 rpm
Inlet pressure	190 bar	92 bar
Inlet temperature	245 K	210 K
Blade diameter	120 mm	180 mm