BOEING 777
THE INSIDE STORY

Graham Warwick looks at the Boeing 777's high-technology air-conditioning and temperature-control system.

Alongside fly-by-wire and new engines, Boeing is going for less glamorous but vital advances in its new 777, having chosen a Hamilton Standard high-technology cabin air-conditioning and temperature-control system which will be lighter and easier to maintain than previous systems.

The system is the first to use condensing-cycle technology, says John Patrick, director of Hamilton Standard's Boeing 777 engineering effort. The result is increased cycle efficiency, lower weight, less aircraft drag and fuel burn and on-condition maintenance, he says.

An airliner environmental control system (ECS) works by tapping engine bleed air — the source of fresh air — and conditioning it to the flow and temperature required in the cabin. The hot, high-pressure bleed air is chilled by air-cycle refrigeration — its temperature is reduced by expanding the air across a turbine.

In a conventional ECS, the bleed air is first cooled by outside ram air before entering a compressor which boosts the turbine inlet pressure to increase the temperature drop across the turbine. Air leaving the compressor is chilled to condense out excess moisture before entering the turbine. Cold air leaving the turbine is routed via the condenser to cool air entering the second-stage turbine. Because the low temperatures required for mixing with cabin air are produced by the second turbine, air leaving the first turbine does not drop below freezing and condenser icing is avoided.

In a conventional-cycle ECS, air has to leave the single turbine at around -40°C to achieve the required 3°C conditioned-air temperature after passing through the condenser and mixing with cabin air at 32°C. In the condensing-cycle ECS, air leaves the first-stage turbine at 2°C, emerges from the condenser at 37°C and is then recooled to -12°C by the second-stage turbine before being mixed with warm cabin air.

The condensing cycle does add some cost and complexity, says Patrick, but the advantages include lower weight and less maintenance. The 777 ECS is 15% lighter than a conventional-cycle system of the same capacity, he says. This results from the new cycle's greater efficiency. Cold air leaving the first-stage turbine heats up as it condenses warm air from the compressor; this heat of condensation is recovered in the second-stage turbine, improving efficiency.

The 777 ECS also has a high-altitude economy mode in which the first-stage turbine is by-passed, minimising both engine bleed pressure and ram-air flow — reducing aircraft drag and improving fuel economy. Flex-foil air bearings are used and the periodic maintenance required by earlier air-conditioning systems is replaced by on-condition maintenance, says Patrick.

The advantages to Hamilton Standard of designing a new ECS have been as great as those to Boeing. The company has applied the philosophy of integrated product development — simultaneous development of the product and the processes to build it — and reduced cycle times dramatically.

When Hamilton Standard won the 777 contract in October 1990 it committed to a development schedule that was half the normal cycle time. The company went from preliminary design to test hardware in six months. Testing of the first prototype began in March and the second system — the 777 ECS a second turbine stage is added. The condenser is located between the two turbines. Cold air from the first-stage turbine is used to condense air leaving the compressor and to cool air entering the second-stage turbine. Because the low temperatures required for mixing with cabin air are produced by the second turbine, air leaving the first turbine does not drop below freezing and condenser icing is avoided.

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