CF6-80C2 modification programmes

The build standard of the CF6-80C2 series has improved during its 20 years of production, and has required few modifications or upgrades. There are some upgrades that are appropriate for airlines operating in harsh environments and suffering poor on-wing reliability.

There are two main upgrade programmes for the CF6-80C2 series: the high pressure turbine (HPT) upgrade, and the new Tech CF6 programme.

HPT upgrade

The HPT upgrade follows early problems with the stage 1 HPT blades. These had poor durability and consequently resulted in poor on-wing and maintenance intervals.

The HPT upgrade modification revolves around the installation of a new HPT blade. The original stage 1 HPT blade suffered from burning, cracking and severe deterioration, and consequently was a main removal driver *(see CF6-80C2 maintenance analysis & budget, page 18)*. The CF6-80C2 is not generally removed due to exhaust gas temperature (EGT) margin erosion, but more due to technical deterioration. The original stage 1 HPT blade was a major example of the CF6-80C2 being prone to deterioration.

The HPT upgrade programme used advanced materials and technology in the HPT to address engine durability and reliability. This is through the use of an improved stage 1 HPT blade, as well as improved HPT nozzles and shrouds.

The ultimate objective of the HPT upgrade programme is to improve the HPT hardware durability. This would have the benefit of increasing removal intervals for shop visits, as well as increasing the percentage of HPT blades that could be repaired rather than replaced. Both airlines and engine shops comment that upgraded engines no longer have HPT distress and deterioration as a main removal driver, and other durability and technical issues now affect the engine's on-wing intervals.

The list price of this kit is $1.7 million, which is expensive for most airlines to consider. The upgrade does not have to be completed in one shop visit, however, and can be completed over a series when material has to be replaced with new parts. Even with a purchase discount, the cost of the modification can only be justified where a large improvement in performance results.

Tech CF6 programme

Like the Tech CFM56 programme launched by CFMI to improve the CFM56, Tech CF6 involves several modifications and upgrades to improve the CF6 series.

Tech CF6 will be available in early 2007, and will consist of three main parts: the high pressure compressor (HPC) durability kit; the HPT durability kit; and the combustor durability kit.

The HPC durability kit stems from various technical and durability problems that operators have encountered over the years. Variable stator vane (VSV) bushings in particular have experienced durability and poor wear problems. The HPC blades themselves were also poor, and leakage and poor HPC performance are the main factor in EGT margin erosion. VSV bushing wear is a main driver in unmodified engines. Block 1 and 2 engines generally suffered from technical reliability and durability problems. Later-build Block 3 engines had improved hardware, and block 1 and 2 engines have been upgraded with block 3 material over the years.

The HPC durability kit is designed to improve the HPC reliability through improved VSV bushings, more durable HPC blades, and HPC blades that are resistant to foreign object damage (FOD).

The HPC blades have been improved by adding a more resistant coating material. The overall benefits are improved HPC durability, less leakage and improved specific fuel consumption retention as a result.

The HPT durability kit offers improved cooling of stage 1 HPT blades through an advanced cooling hole design in the blades, improved stage 2 blade coatings, advanced stage 1 and 2 nozzles for improved durability, and next

The HPT upgrade and Tech CF6 programmes are intended to improve engine performance. Their high cost means they can only be justified for engines that are operating in harsh environments and that suffer short maintenance intervals and high shop visit costs.

generation HPT shroud material to improve leakages.

This programme improves HPT blade and vane durability, again to lessen the general effects of engine deterioration. Like the HPT upgrade programme, the HPT durability kit is intended to reduce HPT blade scrap levels, and overall reduce related maintenance costs.

The combustor durability kit is an advanced multi-hole design on the combustor can inner and outer liner. The modification also includes a temperature-resistant combustor liner material. Both of these designs are intended to improve on-wing life, thereby reducing repair costs.

The Tech CF6 programme has a cost of $400,000 for the HPC module, $300,000 for the combustor liner and $1.9 million for the HPT module. This totals about $2.6 million. Auvinash Narayen, engine programme manager at Total Engine Support, comments that this modification is only likely to be attractive to airlines operating in harsh environments that result in short on-wing intervals and high shop-visit costs. He explains that the cost of the modification will only make economic sense to those engines operating in extreme conditions, and where the modification can offer an an improvement in performance.

Major AD notes

Three major airworthiness directive (AD) notes affect the CF6-80C2. The first of these is AD 2002-25-08, which relates to inspections on the HPC stage 3-9 spool life limited part (LLP). The spool requires an inspection every 2,000EFC, which can force the early removal of engines. Most CF6-80C2s are used as long-haul engines and have removal intervals of 2,000-3,500EFC. Some engines used on the 767 series can remain on wing for longer than this, but the AD allows a partial disassembly of the engine. Narayen explains that a probe is then inserted into the HPC so that the inspection can be made. If the HPC passes, the engine can be reassembled and put back on-wing. Engines used on the 767, A300-600 and A310 on short cycle times of 1.0-3.0 engine flight hours (EFH) tend to be capable of removal intervals of up to 5,000 engine flight cycles (EFC). These would clearly be disrupted by the need to inspect the spool. The simplest way for operators to terminate this AD is for them to replace the affected part with a new LLP, at a cost of $250,000.

The second major AD is 2004-22-07. This relates to an inspection on the old version of the stage 2 nozzle guide vanes. This can be done with a borescope inspection. The initial inspection threshold is at 1,600EFC, which could disrupt planned removal intervals and force early shop visits. Replacement is only required when the vanes fail the condition standard. This AD can be terminated by replacing the affected part numbers with the latest part number for the stage 2 nozzle guide vanes, at a cost of $290,000.

The third major AD is 2006-16-06, which supersedes AD 2004-04-17. It relates to the re-working of dovetail slots for HPT blades following an uncontained failure in an -80A engine.

The AD requires an inspection every 3,000EFC. This is not a problem for most engines, since it will not force removals earlier than planned, except for those operating at the shortest cycle times and achieving up to 5,000EFC on-wing. There is also a limit of 10,000-14,000EFC for re-working the dovetail slots. The actual limit depends on several factors, including the number of accumulated cycles and inspection history, but it will not affect removal intervals. Most operators will re-work the slots during a shop visit. AC