The use of PMA parts in engine maintenance has been declining for the past 10 years. There are a range of PMA airfoil parts and DER repairs available from specialist suppliers for a wide range of older engine types. Both can produce large savings in engine maintenance costs.

The continued use of PMA parts & DER repairs in engine maintenance

The use of parts manufacturer approved (PMA), or reverse-engineered, parts and components is known to provide substantial savings in engine maintenance. While reverse-engineered PMA parts are interchangeable with original equipment manufacturers' (OEMs) parts, their use is, however, challenging and even impossible under certain circumstances. Meanwhile, the use of designated engineering representative (DER) repairs for OEM parts is sometimes necessary, because there is no OEM repair available. DER repairs reduce the cost of engine maintenance, serving as cheaper alternatives to OEM repairs. The use of both has the potential to save several hundred thousands of dollars in an engine shop visit (SV). This raises the issue of when it is possible to use PMA parts and DER repairs in engine maintenance.

PMA parts

PMA and OEM parts are directly interchangeable. PMA parts are developed by companies in direct competition with OEMs. PMA parts, which are reverse engineered versions of OEM parts, have list prices 25-45% lower than the OEMs' standard prices for the equivalent parts.

The biggest impact that PMAs can have is on engine airfoils and gas path components, particularly high pressure turbine (HPT) blades and nozzle guide vanes (NGVs). Individual HPT blades for narrowbody engines have list prices of $15,000 each; there are 72 blades in a full shipset of stage 1 HPT blades in CFM56-3 engines, and 80 in CFM56-5B/-7B engines. A full shipset of blades, for an engine like the CFM56-7B therefore has a list price of $1.3 million. The list price for a shipset of blades is up to $1.8 million for a widebody engine, so when PMA parts are priced at 60% of the OEM's list price, there can be quite significant savings. Examples of other parts are the NGVs and HPT shrouds, which have shipset list prices of about $1.4 million and $250,000 respectively for the CFM56-5B/-7B. This shows how the use of PMA HPT blades and other high cost airfoils, where available, can save several hundred thousands of dollars per SV, even when only some blades are replaced.

New parts and repairs account for 75-80% of an engine SV cost. The potential saving per SV is therefore substantial. "The continued use of PMAs is clearly capable of undermining the OEMs' revenue streams. The OEMs' list prices for engine parts increase at a rate of 6.5-7.0% per year, so they double about once every 10 years," says Nick Hankins, senior engineer at Jet Engine Management. "The OEMs have therefore introduced several policies to limit the use of PMA parts in engine maintenance, particularly with the latest and young generation engine types."

There are two main categories of engine parts, and PMAs. The first is engine airfoils. These are high cost items. HPT blades and NGVs have list prices for individual units in the region of $15,000 and $68,000 in engines such as the CFM56-7B. The use of PMAs with 25-45% lower list prices when replacing just some of the airfoils in an engine during an SV can clearly generate substantial and attractive savings for airlines.

The second category of PMA parts for engines comprises what are often referred to as hardware parts. These are non-airfoil parts, including nuts and bolts, washers, harnesses, rings, spacers, filters, seals, and a range of other small and relatively simple parts. These are cheaper than airfoil parts, but their use can still provide some savings when used over OEM parts.

PMA parts availability

The use of PMA parts in engine maintenance became relatively widespread in the 1990s and early 2000s. This included reverse-engineering many parts in the CFM56-3 by Pratt & Whitney to design alternative parts for the engine. Another example was the development of HPT blades for the PW4000-94 for several main airlines of the Star Alliance, including Lufthansa, Air Canada and United Airlines. Reverse-engineered life limited parts (LLPs) of disks and shafts were also prevalent.

PMA parts became available from several providers. Blade and vane airfoils and gas path components have mainly been available from HEICO and Chromalloy. These are listed on the Federal Aviation Administration (FAA) website. Other providers have since been absorbed and acquired by other companies.

In addition to HEICO, the main suppliers of hardware PMA parts include Kapco, Wencor and Jet Parts Engineering.

Chromalloy and its subsidiary Belac are the largest providers of airfoil PMA parts, offering the widest range of airfoil and gas path part numbers (P/Ns) for the widest range of commercial engines, including most older generation Pratt & Whitney (PW), General Electric (GE), CFMI and International Aero Engines (IAE) engine types.

These include the JT8D, JT8D-200, JT9D, PW2000, PW4000-94 and PW4000-112 Pratt & Whitney engines.

Chromalloy provided HPT and low pressure turbine (LPT) blades, high pressure compressor (HPC) vanes, and the rear turbine case for the JT8D-200. The maintenance market for this engine has now almost disappeared.

Chromalloy has a wide range of parts

for the PW2000 series, including stage 7-17 HPC blades, the HPT stage 1 duct segment, and the HPT stage 2 vane assembly.

Parts for the PW4000-94 series include stator shrouds for five stages in the HPC, the first stage HPT blade (provided by Belac), and a few other parts.

Parts for the PW4000-112 include shroud segments for the seven stages of the HPC.

Parts provided by Chromalloy for GE engines include the CF6-50C, CF6-80A, and CF6-80C2. There are relatively few parts for the CF6-50C and -80A series. Parts for the more prominent -80C2 series are the first- and second-stage HPT blades provided by Belac, and the first- and second-stage HPT vane assemblies. Chromalloy also provides the HPT inner seal. HEICO Aerospace provides HPC blades for the CF6 family.

Parts for CFMI engines are for all five main types: the CFM56-2, CFM56-3, CFM56-5A/-5B, CFM56-5C and CFM56-7B.

The main parts Chromalloy provides for the CFM56-3 series are seals for the fourth to eighth HPC stages, and the LPT NGV segment assembly.

It provides the HPT NGV segment assembly for the CFM56-5A and -5B, and the first stage LPT NGV segment assembly.

Chromalloy parts for the CFM56-7B are the fan blade platform, the HPT NGV segment assembly, and the LPT first-stage NGV segment assembly.

HEICO Aerospace provides HPC airfoils for the CFM56-3, -5B and -7B series engines. In the case of the -7B, this is the older non-Tech Insertion standard.

Jet Parts Engineering provides a small number of airfoil and gas path parts for the CFM56 family, including HPT seals and HPC shrouds for the CFM56-5B and -7B engines. In total, HEICO provides PMAs for 17 of the 136 P/Ns in the -5B's HPC.

Chromalloy's subsidiary Belac also provides airfoil PMA parts for the V2500-A5 series. The most important is the second-stage HPT blade.

There are also a small number of airfoil and gas path PMA parts available for the CF34 family, including HPT seals provided by Jet Parts Engineering for most CF34 series.

The range of airfoil and gas path PMA parts available for the wide range of older engines types clearly makes it possible for airlines to achieve substantial maintenance cost savings. In addition to the parts available, airlines have shown interest in developing PMA alternatives for a larger number of PW2000 and PW4000-94 P/Ns, as well as some P/Ns for the GE90 engine family. "Development of PMA airfoil parts is airline customer-led," says Patrick Markham, vice president of technical at HEICO Aerospace. "We would develop reverse-engineered airfoil PMAs if sufficient airline interest was there."

Hardware PMA parts

In addition to airfoils and gas path parts, there are several suppliers of mainly external hardware parts. The main providers include HEICO Aerospace, ADPma, Jet Parts Engineering, Wencor, KAPCO and Avio Diepen. Previous providers of engine hardware PMA parts included Aaxico, Avion Global, and Coast Air. All have been acquired by KAPCO over the past seven years.

Hardware parts include simple and single item parts, but also some more complex engine accessory and line replaceable unit (LRU) components, such as bearings, drive units, fuel pumps, and integrated drive generators (IDGs).

These are generally more acceptable to OEMs, but there is still overall resistance to the use of PMAs in engines, even though they can save several thousands of dollars per engine SV, and so contribute to overall savings in engine maintenance costs.

ADPma provides a range of hardware PMA parts for narrowbody engines and the CF34. These include brackets, seals, liners, gaskets, bushings, gear assemblies, rings and couplings.

Jet Parts Engineering manufactures

While the use of PMA airfoils poses many difficulties for airlines, there is a wide range of parts available for older generation types. Not only do PMA parts save a lot of cost in the maintenance of older engines, they are also sometimes the only parts available.

more than 300 P/Ns for hardware parts for the CFM56, CF6, CF34, PW2000, PW4000, GE90, RB211 and JT8D engines. These include nuts, bolts, bushings, gaskets, seals, bearings, shrouds and moving parts such as actuator arms and valves.

PMA opposition

Opposition to the use of PMA parts increased during the mid-2000s. Several factors combined to limit or even prevent their use by airlines in engine maintenance.

The first has been the refusal of the OEMs to honour warranties on PMA airfoil and hardware parts, and provide technical support.

Airfoils are often referred to as ‘influencing parts’, since the blades and vanes in engines will always be mounted on disks and shafts. Since airfoils interact with disks, they can affect their operation, especially where one of the two joined parts could have been manufactured out of limits, causing problems with the mated part. An incorrectly cast blade could therefore lead to distress of a disk.

LLPs are always provided by the OEMs, and have high list prices. Examples are the CFM56-7B, which has 18 LLPs with a shipset list price of $3.6 million. The shipset of LLPs for a GEnx engine costs $9.0 million.

The main core engine assemblies of a two-shaft engine include the intake fan, low pressure compressor (LPC), HPC, combustor, HPT and LPT. All have their own LLPs and airfoils, as well as cases and external components and parts. The core engine modules are all connected in series, so ultimately the operation of one module can be influenced by another, as well as by the externally-mounted components.

The hardware parts are mainly used on the outside of an engine to mount accessory components and LRUs on the engine cowling.

OEMs have used several methods to limit, or even totally prevent, the use of PMAs.

One method has been for engine OEMs to refuse to honour warranties on their own parts if a PMA part has been used in the engine, or to provide technical support for the same reason.

Not only do OEMs refuse to honour warranties or provide technical support for LLPs that have PMA airfoils mounted on them, but they will also make the same decision for one module of the core engine when a PMA airfoil is mounted on a disk in another module. Moreover, OEMs do not honour warranties and refuse technical support, even if only hardware PMA parts are used on any part of the engine.

This OEM policy has completely deterred airlines from using any PMA airfoil and hardware parts in any module or assembly of the engine, but not when engines are being operated in the last few years of their life. Market values of the engine and modules will be low, and maintenance costs can be minimised by using used serviceable material (USM), PMA parts, and time-continued or ‘green time’ modules. Airlines will not be concerned about claiming warranties, since these will have expired for older engines.

“The refusal to honour warranties and provide technical support to prevent PMA part usage in engines is legitimate. An OEM is within its rights not to honour a warranty on an LLP, such as a disk, or an assembly where a PMA blade or vane is mounted, for example,” says Hankins. “This is because a PMA blade or vane has been manufactured by another provider, so the OEM has no design or manufacturing data about that part. An OEM can use a standard statement which effectively says that it 'cannot validate the validity of a part'. This includes being unable to validate the life of its disks and shafts, and therefore cover their warranties, if they were mated with PMA parts."

Several other factors have reduced the use of PMA parts, particularly airfoils, over the past 15 years. These revolve around engine remarketability and market values. "A major influence has been the growing portion of engines that are owned by specialist engine lessors," says Hankins. "These only account for spare engines. Also, up to 50% of aircraft are owned by operating lessors, and are on relatively short-term leases. Aircraft and engines are frequently returned to lessors after relatively short lease terms, to be remarketed to other airlines. Engine and aircraft lessors therefore have an influence over a high percentage of all the engines in a fleet.

Most lessors have adopted clear policies of not allowing PMA parts in their engine assets, especially over the past 10-15 years. These are stipulated in lease return conditions. They may also stipulate that PMA parts are not used in engines at any time during the lease term. This is explained by concerns over the ability to receive technical support from the OEMs, the ability to make warranty claims, a reduced ability to remarket their aircraft and engines either through new leases or sales, and so an impact on market values.

The widespread use of lessors to finance equipment means this collective policy by the majority has had a large influence on the use of PMAs in engine maintenance over the past 10 years.

"Most new entrants into engine leasing have non-PMA clauses, and a main concern is the negative effect on engine values that PMAs can have," says Hankins. "A factor in this is that the assessed values of engines assume that all parts installed in an engine are OEM-sourced. The perception is that PMAs will reduce engine market values."

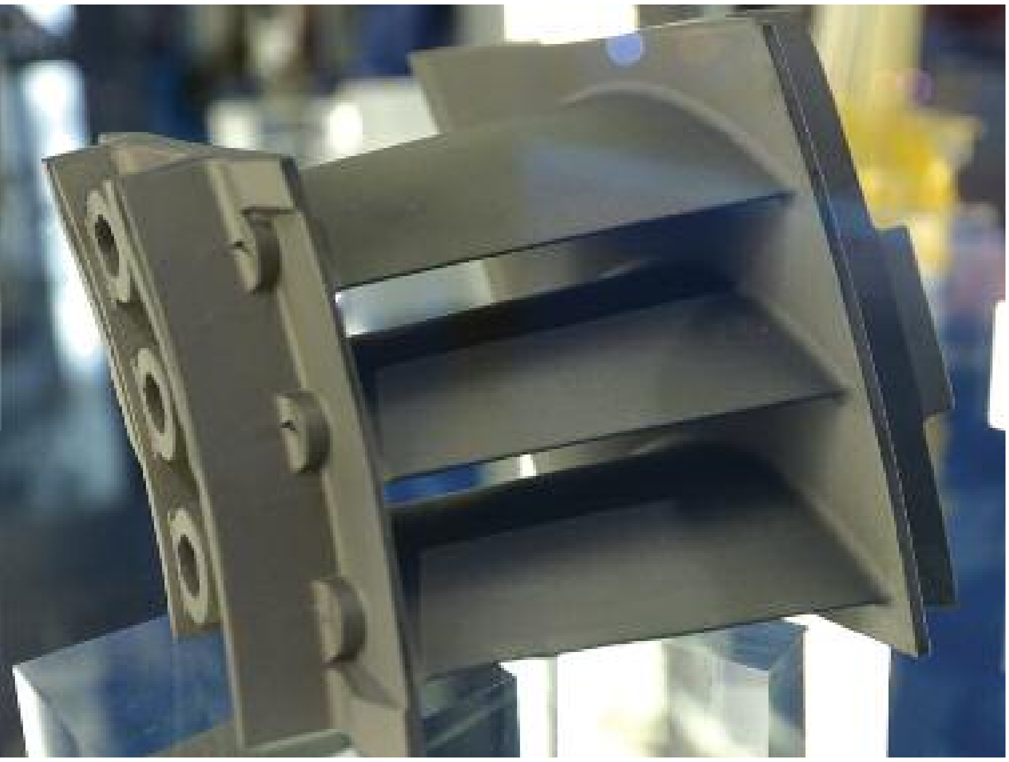
This is actually the case in the US, where accounting rules reduce the book value of all types of hardware assets if non-OEM parts are installed. Because of this, engine OEMs can provide an audit for an engine's configuration with respect to hardware installed, and declare the engine OEM-certified if it has 100% OEM parts installed. The audit is made on the basis of the engine's maintenance records.

A total ban on PMA in leased engines is not always the case, however. "Some lessors work with the lessee and its maintenance shop to determine if using PMA parts is viable, so as long as the risk is mitigated," says Gregoire Lebigot, president and chief executive officer at Vallair. "This is why non-critical and non-rotating parts are more easily accepted."

Economics is always the main factor. "The 6.5-7.0% annual rate of price increases for OEM parts outstrips rates of inflation, and so puts pressure on maintenance costs. This only applies where new OEM parts are being acquired for time and material (T&M) maintenance contracts," explains Hankins. "List prices are less likely to be paid by airlines and independent maintenance shops where high volumes are bought. Airlines use OEMs' maintenance cost per hour (MCPH) or power-by-the-hour (PBH) maintenance contracts over an extended period. These are designed to provide a predictable cost for the airline. OEMs can offer these where parts are effectively priced at a little over the actual cost of manufacturing them, rather than at the annual escalating list price. The same applies to the other cost elements of MCPH-style contracts. These are based on the actual cost of labour, cost of manufacturing parts, and overheads. The relatively low cost of manufacturing new engine parts means that OEMs can offer them at competitive prices compared to PMA parts.

"The implications of this are that MCPH maintenance contracts can be priced competitively compared to T&M contracts offered by airline or independent engine shops," says Hankins. "Airline and independent engine shops may be able to offer PMA parts to the airline customer if that is what is required. An OEM has the ability, however, to offer a competitively priced MCPH package that provides almost zero risk and keeps an engine with 100% OEM parts that removes value and remarketability risk. This is effective at preventing the use of PMA parts. Moreover, it illustrates the difficulty that airline-operated and independent engine shops have competing with OEM shops."

This issue becomes less significant as engines get older. They are less likely to be managed under MCPH-style OEM contracts from about 15 years of age. An increasing portion of engines is maintained under different maintenance contracts as



The use of DER repairs on parts is less contentious than the use of PMA parts. While DER repairs can save costs in shop visits, airlines have the alternative used serviceable material.

they age, and the possibility of using PMA parts increases. "It does in fact become absolutely necessary to use PMA parts for mature engine assets when out-of-production parts are difficult to source," says Lebigot.

The same applies to the use of USM. Overall there is increased scope for airlines to minimise their engine maintenance cost exposure. This is still not the case, however, with engines owned by lessors.

Another issue affecting the use of PMA parts is that younger generation engines, the CFM56-7B being a prime example, have longer removal intervals between maintenance SVs. Depending on thrust rating, the CFM56-7B can achieve first run intervals of 11,000-20,000EFC. The V2500-A5 is capable of intervals of 14,000-19,000EFC in the medium-rated engines, and longer than 24,000EFC for lower-rated variants.

As a result they have fewer planned SVs in their operational lifetime, so fewer parts get changed. The first SV is when a high percentage of parts will get repaired or replaced with OEM parts. The second SV and their removals provide the small number of occasions when there is a chance to use PMA parts.

Despite this, there are still factors that limit the opportunity to benefit from using PMA parts. The prime example is that engine OEMs continue to improve the design of engine hardware and gas path parts. The improvement programmes for the CFM56-5B and -7B are the best examples; these included hardware upgrades that improved the durability of parts. This made it risky to develop PMA parts, since the new PMA part could be made obsolete by the OEM's improved part after a short period of time.

CFM & IATA agreement

In September 2018 engine manufacturer CFM signed an agreement with the International Air Transport Association (IATA) to allow an increased level of competition in the CFM56 aftermarket. This followed complaints by members of the Association of European Airlines (AEA) relating to what they viewed as anti-competitive behaviour by OEMs in the engine technical support and maintenance market.

The signed agreement, which came into force in February 2019, was intended to increase competition through several means. These included CFM charging engine shops lower or zero licensing and technical support fees, permitting the use of non-CFM parts and parts repairs, and honouring the warranty coverage of CFM components and repairs when the engine has non-CFM parts installed.

"The CFM/IATA agreement has special implications for the use of PMA parts," says Patrick Markham, vice president of technical at HEICO. "Things always move slowly, however. Before the agreement, CFM, like other engine OEMs, would not honour warranties on disks and shafts if a PMA airfoil had been mounted on the shaft in the event of a problem, such as distress in the disk. Moreover, it would not provide technical support to the airline. CFM would also have been unlikely to provide technical support or honour a warranty if there had been a problem in another module where the PMA airfoil had been installed. Furthermore, technical and warranty support would be denied even if just a PMA washer, nut, bolt or filter had been used on the outside or anywhere on the engine.

"The agreement between CFM and IATA has changed things. The only incidence in which CFM would not honour the warranty and provide technical support is if a PMA part is used as an influencing part on an LLP, and the cause of the problem was found to be the PMA part," continues Markham. "An example is a PMA compressor blade being installed on a HPC disk, and the blade being found to be the cause of a problem, such as distress. Conversely, under the terms of the agreement, CFM will honour the warranty for the disk and provide technical support to the airline where a PMA blade was used together with an OEM disk, and it was found that the disk was at fault. In other words, the agreement is very specific about which part is causing the problem when honouring warranties and providing technical support."

Markham says that since this agreement has come into effect, airlines' concerns over warranties and technical support are going away. Both GE and CFM will give technical support for all issues relating to an engine with PMA parts installed, unless the PMA part can be shown to be the cause of the problem. This now means that, in the case of a problem with a PMA HPC blade mounted on a disk, CFM and GE will still honour the warranty and provide technical support for the fan disk if it has a technical issue. Moreover, hardware PMA parts can now be used without any concerns about warranties not being honoured and technical support not being provided. This is because the CFM/IATA agreement specifies that the PMA must be the cause of a technical problem. The restrictions for using PMAs in CFM engines were far more onerous before the agreement was signed."

Possible future PMA use

While the use of PMAs is easing in the case of CFM engines, it remains restrictive for many engine types. Markham notes that the use of PMAs on CFM engines is first likely to be with hardware parts: "There are enough airlines that want to use airfoil and gas path PMAs, especially as their engines age. At this stage of an engine's life, however, there is competition from USM. We will develop PMAs for more airfoil and gas path P/Ns for the main engine types if the demand is there."

It is generally easier for larger airlines that own a portion of their fleets and still operate their own engine shops to use PMAs. Delta Airlines is an example. It uses PMAs in its older engines at a rate of 6-32% for the CFM56-7B, V2500, PW2000, PW4000, CF6-80C2 and CF6-80E fleets. About 39% of the PMA parts that Delta uses are Air Transport Association (ATA) Chapter 72 parts, which are in the engine turbomachinery. American Airlines and United Airlines also use engine PMAs.

"SAS is also very pro the use of PMA parts, and is using hardware parts on its engines," says David Beal, senior vice president sales and program management at Sheffield Aerospace.

DER repairs

The use of DER repairs is less contentious than PMA parts. Clearly, all parts in a new engine are provided by the OEM. Some will need replacement at the engine's first SV and others can be repaired if within specified engine shop manual (ESM) limits. Using hi-tech and complex repairs can clearly save a lot of money if the durability of the repaired part does not limit the engine's subsequent removal interval compared to using a new part.

The main issue is the airfoil and gas path parts. Many DER repairs have been developed because an OEM repair is not available in the ESM; these repairs have then been approved by the OEM. Such OEM repairs are not viewed as negatively as DER repairs that have been developed as alternatives to OEM repairs. Once specific DER repairs have been developed, as an alternative to simply scrapping a part, the result has often been to stimulate the OEM to develop a repair for the ESM.

"DER repairs are actually well developed, and their durability is equal to OEM repairs," explains Hankins. "Some DER repairs are complex, and include techniques such as laser drilling. Others are blade coatings that allow airfoils in the hot section to withstand the high temperatures in the HPT and first stages of the LPT.

"OEMs have problems with performing their own repairs on top of a DER repair, because of concerns about the legitimacy of the parts being installed back in the engine," says Hankins. In this case, the OEM repair would be performed at a second SV, following the DER repair at the first. The part repaired a second time would thus be installed in the engine on its third on-wing interval.

"An OEM repair performed on top of a DER repair may not even be approved, and maintenance contracts with OEMs often see any parts with DER repairs being purged out. Lessors are very sensitive to this, and there have been cases where parts with DER repairs have had to be removed at lease return, resulting in very expensive SVs for airlines," says Hankins. "This means it is more likely that DER repairs will be used by independent and airline-owned engine shops. This will be performed on owned and older engines."

DER repair providers include Chromalloy, MTU Maintenance, and some airline-owned engine shops.

Chromalloy provides DER repairs for a wide range of airfoils on a range of engine types. This includes the RB211-535E4. The repairs for various engine types include re-airfoiling an NGV for several engine types.

Airline-owned engine shops that have their own specialist divisions for developing DER repairs and providing them for engine maintenance include Lufthansa Technik and Air France Industries. Lufthansa Technik's specialist DER repair division is EPAR, while CRMA is the specialist engine parts repair provider for Air France Industries.

Overall the range of DER repairs from providers in the industry gives airlines the opportunity to make savings in the maintenance of most engine types. "The use of PMA parts is less contentious than PMA parts," says Hankins. "Moreover, DER repairs can be used on PMA and OEM parts." AC

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