Investigation on the serious incidents to PW127 engines

Factual information of the events

1. ATR42-500 registration YR-ATG on 17th of June 2011 at Budapest Airport (LHBP)

After take-off from runway 31L, at around 1200 ft AGL, the crew noticed what sounded like engine stall of engine N°2. They set the affected engine to Flight Idle. Shortly thereafter the Engine Low Oil Pressure Warning came in, followed by Engine Fire Warning.

The crew performed – from memory – the required emergency checklist actions (in-flight engine fire or severe mechanical damage). The propeller of the malfunctioned engine was set to feather. The crew declared an emergency by reporting MAYDAY and requested an immediate landing. The Tower secured runway 13L for the emergency landing.

The captain took the aircraft into a tight right turn while the first officer initiated the fire extinguishing system by discharging first the agent N°1 then N°2. The fire inside the engine nacelle was successfully put out.

The passengers saw the flames and the smoke coming out of the engine nacelle. Some smoke was visible inside the main cabin which caused panic among the passengers.

A single engine landing was performed on runway 13L. Once the aircraft stopped on a taxiway, the passengers were evacuated on the captain's command.

The aerodrome emergency services were waiting for the aircraft but there was no need for intervention because the fire had already been stopped.

Based on the information received from the operator, the crew used a QRH issued by the manufacturer in December 2009.

2. ATR72-212A registration OY-CIM on 13th of September 2011 at Copenhagen Airport, Kastrup (EKCH)

Shortly after take-off from runway 22R while climbing through approximately 134 feet Radio Altitude (RA), a cockpit Master Warning was triggered referring to left engine low oil pressure. The cockpit Master Warning was silenced. Subsequently, a cockpit Master Caution was triggered referring to left engine high Inner stage Turbine Temperature (ITT). Smoke was present in the cockpit and in the passenger cabin. The flight crew decided to shut down the left engine (memory items). While climbing through approximately 750 feet RA, a cockpit Master Warning was triggered referring to left engine fire. The cockpit Master Warning was silenced.

A Mayday call to Kastrup Tower was made. A left hand visual circling to runway 22L was initiated. The flight crew noted the left engine fire warning lights. Sequentially, both engine fire agents were discharged and the flight crew decided to land on runway 30.

Descending through approximately 486 feet RA, a cockpit Master Warning was triggered. The Master Warning was silenced.
A single engine landing was performed.

On runway 30, the flight crew observed that the fire had extinguished and they cancelled the emergency evacuation of the aircraft.

The total Digital Flight Data Recorder (DFDR) recorded airborne time was five minutes and two seconds.

3. ATR72-212A registration I-ADCC on 3rd of October 2011 at Firenze Airport, Peretola (LIRQ)

After a bleed-off aircraft configuration take-off from runway 23, at around 400 ft AGL, the cockpit Master Warning was triggered referring to Engine 1 low oil pressure, but shortly after any malfunction indication disappeared.
Climb continued till acceleration altitude with one more short Eng1 oil LP indication.
At 1570 ft, when climb sequence was completed and Bleed valves switched on, oil LP indication popped up again while ITT value dropped to zero.

In absence of additional abnormal parameters, the crew believed in a faulty indication, but soon visual and aural warnings notified an Eng 1 fire condition, together with smoke in the cabin.
So, an in-flight engine fire emergency procedure was applied by shutting down the engine and attempting to discharge the extinguisher agent.

An emergency call was made to Firenze APP and the crew stated his intention to come back to the airport to land on runway 05.
Approach and landing took place uneventfully and the precautionary fire brigade assistance was provided when aircraft stopped on Taxiway P. Precautionary evacuation was carried out at that stage due to "HT brake warning light on".
The investigation highlighted that the "fire or severe mechanical damage" emergency procedures were revised by ATR at least three times in fourteen months (only the month is edited on the revised pages) and introduced with a consistent delay in the AFM owned by the operator, therefore being effective for the crew.

Common Findings

During the joint meeting held at ANSV premises in Rome on 7-9 Feb. 2012, the safety investigation authorities in charge of the three events verified the following main commonalities:

- all events occurred at initial climb;
- the events were all due to the initial distress of a Power Turbine 1st stage rotor blade causing subsequent damages and heavy unbalance of the whole PT assembly, further unbalance of the LP rotor through No. 6 & 7 bearing housing, and final oil leakage due to breaking of No. 6 & 7 bearing compartment retaining bolts and distress of the radial transfer tubes. Fire was then originated by such a leakage in presence of hot parts;
- in all these serious incidents distress of the PT1 rotor blade was due to a crack propagated from an internal casting defect (shrinkage porosity) in the vicinity of the blade core pocket. Propagation is in accordance with a Low Cycle Fatigue mechanism.

Recommendations

Based on the information gathered up to now and shared among the safety investigation authorities, Transportation Safety Bureau of Hungary (TSB) considers necessary to issue the following recommendations:

Recommendation BA2011-120-4P-1A

Motivation:
Investigations revealed that the emergency procedure (air conditioning smoke) did not direct the flight crew's decision making on how to remove smoke from the cockpit and cabin if smoke persisted.

Comparing to similar aircraft types (Saab 340, Fokker 50 and Dash 8), differences were noted and it was found that the ATR smoke emergency procedures seemed not to be sufficient if smoke was persisting and cockpit/passenger cabin ventilation was required.

Although in the serious incidents on subject this finding was not considered as a contributing factor, however, whether or not a similar incident takes place shortly after takeoff or at any altitude, no ATR smoke removal emergency procedure seemed to be at the disposal of a flight crew. For that reason, the signing investigation authorities regarded this finding as a flight safety issue, which needed further consideration.

Addressee: EASA

Text: **To review the emergency procedures on ATR aircraft in order to ensure efficient removal of persisting smoke and appropriate cockpit/passenger cabin ventilation.**

Recommendation BA2011-120-4P-2A

Motivation:
Fatigue failure of PT1 rotor blade was found a recurrent failure on this engine, with a total of at least 28 events already due to this root cause in the timeframe 2005-2011, with a peak in 2008-2009.

As a consequence, in April 2008 the engine manufacturer improved the X-Ray inspection on the new blades by introducing an additional view specifically to be taken in the area of interest (core pocket). In addition, all retained X-Ray films were reviewed and 68 blades were limited in terms of service life in accordance with SB 21766.

Furthermore, a previous recommendation was issued in 2010 by ASC-Taiwan as a result of a similar event occurred during take-off at Magong airport on 11 Feb 2009, requiring "to incorporate measures to efficiently detect the shrinkage porosity which beyond maximum allowable limits".

However, the recurrence of the failure in a wide range of accumulated cycles/flight hours shows that time to rupture can't be predicted and it is mainly dependant on the size of the original shrinkage porosity. So, all other blades currently in service could be potentially affected by the same kind of deferred fatigue failure when a defect, not revealed at the first and only check for blades manufactured before 2007 or not detected at the second check in case of blades manufactured between 2007 and 2008, is big enough to propagate a crack.

Addressee: Transport Canada

Text: **To consider the need to early withdraw from service the PT1 rotor blades manufactured before the introduction of NDT improvement or, alternatively, to urgently introduce a one shot X-Ray inspection on all those blades having accumulated a number of cycles beyond a limit to be established (e.g. 2000), specifically focused on the pocket area to exclude the presence of a fatigue crack.**

Recommendation n. BA2011-120-4P-3A

Motivation:
One more fatigue breakage was observed on new PT1 blades manufactured after implementing the improved X-Ray inspection, although at the moment they only have accumulated a limited number of cycles.

In effect, in absence of a robust POD (Probability of Detection) study and with no knowledge of the minimum casting defect able to promote the crack growth, it seems there is still some uncertainty on the effective improvement achieved in terms of reliability of the parts.

The significant increase in rejection rate at production, being only limited to 2011, at the moment can't be considered as a proof of the effectiveness of the modifications introduced since 2008.

Addressee: Transport Canada

Text: **Taking into account the high volume of PT1 rotor blade production, to consider the opportunity to introduce in production, at least as a temporary measure, an additional Computed Tomography check on a representative sample of blades in order to gain confidence on the effective improvement achieved through the review of the X-Ray methodology implemented in 2008.**

Recommendation BA2011-120-4P-4A

Motivation:
All events were due to a severe mechanical damage and occurred at initial climb, although not necessarily immediately recognized as such by the crews and treated as an in-flight fire at a following stage.

The investigation highlighted an uncertainty on the emergency procedure in force at the time of the event, considering the several amendments issued and ongoing on this subject.
Examination of the existing documentation, namely the EU-OPS 1.130, seems not able to clarify in mandatory terms the timeframe and the procedures to achieve the effective operator compliance on this item when the AFM modification is not accompanied by a dedicated AD.

Addressee: EASA

Text: **To consider the need to harmonize the procedures, or to review the existing documentation as necessary, in order to establish in all cases a time limit within which to make effective in the AFM owned by operators the amendments approved by EASA.**

Recommendation BA2011-120-4P-5A

Motivation:
ATR AFM Temporary Revision of the "engine fire at take-off" emergency procedure approved in Nov. 2011 introduced a large number of further memory items.

The increasing number of memory items seems to reflect a general trend in the implementation or review of the emergency procedures; however, it seems highly desirable that a careful consideration take place on the potential negative effects of the consequent build-up of the crew workload.

In this case, in addition to a delay of the shutoff action on the affected engine, it may potentially cause an area of hazard taking into consideration the criticality of the phase of flight.

Addressee: EASA

Text: **To promote an internal debate (e.g.: dedicated working group, workshop, etc.) to carefully evaluate the pros and cons of a continuously increasing of memory items introduced in the implementation or review of the emergency procedure, mainly when to be applied in a critical phase of flight.**

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