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ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation AO-2006-005
Final

Engine malfunction: rejected takeoff Mount Isa, Qld

16 December 2006

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ABSTRACT

A Saab 340B passenger aircraft, registered VH-UYA, experienced a left engine malfunction during the take-off roll at Mount Isa airport. In response to the abnormal engine condition, the flight crew rejected the takeoff and shut down the left engine. When the engine was subsequently disassembled by the engine manufacturer, it was revealed that a single stage-four power turbine blade had fractured at the blade root. The liberated airfoil section caused secondary damage to the power turbine and exhaust sections. Metallurgical analysis of the fractured blade revealed that a pre-existing crack had been present at the blade root for a significant period of engine operation prior to the incident malfunction.

FACTUAL INFORMATION

History of the flight

On 16 December 2006 at approximately 1050 Eastern Standard Time[1], a twin-engine Saab 340B passenger aircraft, registered VH-UYA, was scheduled to depart Mount Isa for Townsville, Qld. On board the aircraft were 27 passengers and three crew. Shortly after commencing the take-off roll, the flight crew noted anomalous torque fluctuations from the left engine. The crew elected to continue the takeoff but the left engine fluctuations continued to rise as the aircraft accelerated down the runway.

When the aircraft had accelerated to approximately 110 kts, it was reported that the aircraft's left engine propeller auto-coarsened and numerous warning lights on the cockpit annunciator panel illuminated. Given that the take-off decision speed, V1[2], had not been exceeded, a decision to reject the takeoff was made by the pilot in command (PIC) of the aircraft.

In order to slow the aircraft, both engine power levers were set to ground idle and maximum braking was applied. The left engine was shut down once the aircraft had stopped. An audible mechanical whine/rumbling noise was heard by the crew as the left engine spooled down. In order to alleviate any safety concerns, the PIC briefed the passengers on his decision to reject the takeoff. There were no injuries.

After the aircraft had been returned to the gate for passenger disembarkation, the crew were unable to restart the left engine. A preliminary onsite engine inspection by the operator's maintenance engineers revealed that the power turbine (PT) had sustained damage.

Due to the lack of authorised facilities in Australia, the operator sent the engine to its manufacturer in the United States for complete disassembly. The Australian Transport Safety Bureau (ATSB) requested the National Transportation Safety Board (NTSB) to supervise the examination. The ATSB also requested the NTSB to conduct a

1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours

2 The maximum speed at which, should a critical engine fail, a pilot can safely stop the aircraft without leaving the runway. V1 for a particular aircraft is variable for each flight and is calculated prior to takeoff. Weight, altitude and temperature are some of the factors used in the V1 calculation.

metallurgical examination of the stage-four PT blades to determine the mode of blade failure.

Pilot information

The information below summarises the operational qualifications and experience of the PIC of the Saab 340B at the time of the occurrence.

License category	ATPL
Total flying hours	6100
Total on Saab 340B	350
Total last 90 days	150

Aircraft and engine information

The information below summarises the relevant information about the General Electric CT7-9B turbopropeller engine. A review of the engine's maintenance records revealed that in July 2005 at 16,781 hrs, the left engine had undergone a major overhaul to repair a damaged hot-section. A new stage-four PT disk and blade set were among the numerous parts replaced at that time.

Manufacturer	General Electric Company
Model	CT7-9B (Qty 2)
Serial Number	785-507
Total hours	19,097
Total cycles	16,674

Recorded Data

Recovery and analysis of the data from the flight data recorder (FDR) that had been fitted to the Saab 340B was performed by the ATSB in Canberra.

The FDR data indicated that both engines started and operated in a normal manner during the take-off roll until, at about 60 kts, the left engine exhibited fluctuations in fuel flow, inter-turbine temperature (ITT), turbine pressure and torque. As the aircraft continued to accelerate, the left engine torque began to reduce.

After the decision to reject the takeoff was made, the recorded parameters indicated that the aircraft reached a maximum recorded speed of 109 kts. As the aircraft slowed, the left engine torque fell to zero and the propeller speed decayed; coincident with a dramatic rise in ITT (greater than 1,000 ºC).

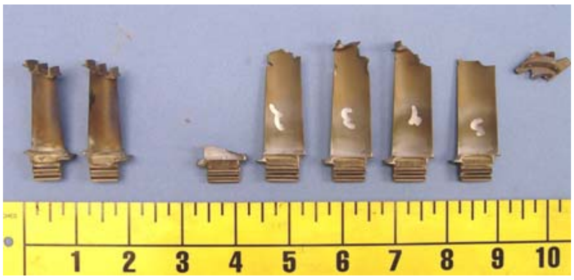
Examination of FDR data from the flight prior to the incident at Mount Isa, did not reveal any abnormal indications in the operation of either engine that would have alerted the crew to a propulsion-related problem.

Engine investigation findings

Engine examination

A detailed inspection report[3] of the teardown process was provided by the engine manufacturer. The teardown confirmed that a single stage-four PT blade (SN R4PUA) had fractured at the airfoil root. Secondary damage in the form of tip separation had occurred to the four adjacent PT blades due to impact with the liberated PT blade segment (Figure 1).

Figure 1: Separated and damaged stage-four PT blades



Additional secondary engine damage mentioned in the report included; numerous indentations and impact punctures to the exhaust frame, severe circumferential mechanical rubbing of the PT shaft outer surface due to an out-of-balance stage-four PT rotor, and heat discolouration of the stage-three PT blade set and stage-four nozzle guide vanes.

Power turbine blade - metallurgical examination

Metallurgical examination of the fractured stage-four PT blade was performed jointly by the NTSB and the engine manufacturer. The following text provides a summary of their findings[4].

Visual examination of the PT blade revealed that it had fractured close to the blade root (Figures 2 and 3). The fracture surface was divided into either that of tensile overstress, or a 'dark'

3 General Electric Engine Services, Preliminary engine condition report, Work Order 288029, February 2007

4 General Electric Aircraft Engines, SRD/EI Closeout Report, April 2008

oxidised zone. The oxidised zone extended from the trailing edge of the airfoil surface through to about the mid-chord region, while the region of overstress extended forward to the leading edge. Although the oxidation partially concealed the underlying fracture surface, no evidence of fatigue or any other such progressive failure mechanisms were observed.

Figure 2: Fractured stage-four PT blade at the airfoil root

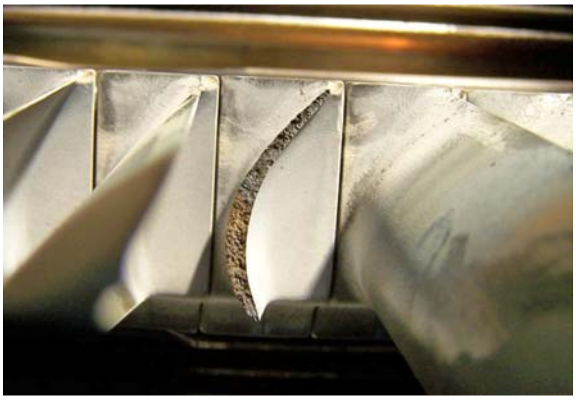
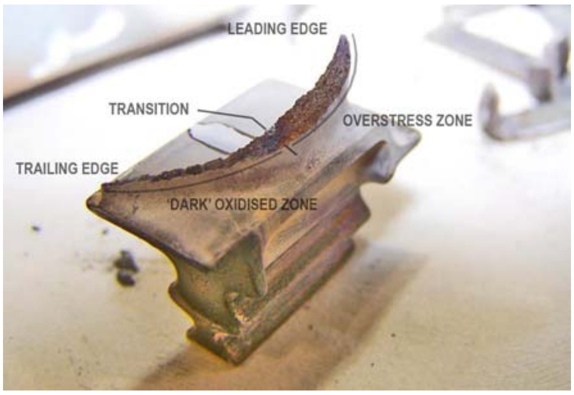


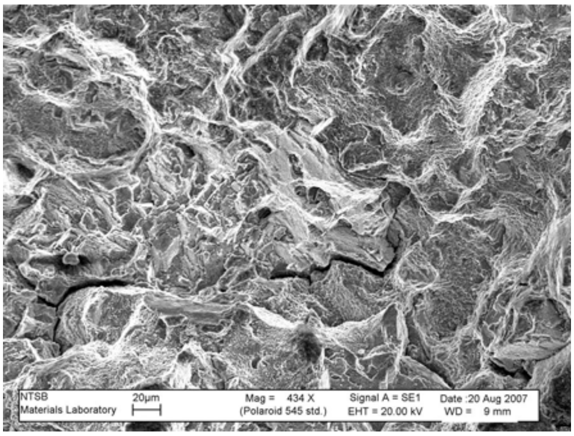
Figure 3: Fractured stage-four PT blade (SN R4PUA)



To further confirm the mode of fracture, the finer features of the fractured PT blade surface were examined at high magnification using a scanning electron microscope (SEM). Most detail in the oxidised region was unresolvable. However, tensile dimples and secondary cracks were present in the overstress region (Figure 4).

Metallographic sectioning of the fractured blade did not reveal any evidence of blade creep that might have otherwise suggested exposure to adverse operating temperatures.

Figure 4: SEM image of the fracture surface showing only features of tensile overstress



No casting or machining defects associated with the manufacturing process of the blade were identified.

ANALYSIS

Engine failure

The left engine from the Saab 340B aircraft malfunctioned during the take-off roll, resulting in the flight crew rejecting the takeoff. When the PIC of the aircraft recognised and reacted to the engine problem, the aircraft speed had not yet exceeded V1. Proper management of the inoperative engine at that critical stage during the takeoff ensured that the crew were able to safely stop the aircraft without any adverse consequences.

Subsequent disassembly of the left engine revealed that a single, stage-four power turbine (PT) blade had fractured close to the blade root. The liberated airfoil section from that PT blade then impacted and caused secondary damage to several adjacent stage-four PT blades, and numerous downstream engine components. As a result of that damage, the engine's ability to produce torque was affected. This fact is reflected in the analysis of the recorded parameters from the aircraft FDR.

Shortly after commencing the take-off roll and as the aircraft accelerated beyond 60 kts, the FDR data analysis indicated that various parameters began to fluctuate including the torque output from the left engine. Examination of the data from the previous flight did not indicate any engine anomalies. Such detail showed that the PT blade loss occurred during the incident takeoff at Mount Isa.

PT blade failure

The entire set of stage-four PT blades had been installed into the engine as new items at the time of the last overhaul. Since then, the blades had accumulated 2,316 hrs of service.

The metallurgical examination carried out on the fractured PT blade (SN R4PUA) found no evidence to suggest that the failure resulted from a deficiency within the material or production of the component.

Examination of the PT blade fracture surface revealed that it had fractured in tensile overstress at the blade root. Half of the fracture surface had been heavily oxidised. The 'zonal' oxide layer indicated that a pre-existing crack had been present in the PT blade for a significant period of time during engine operation. No evidence was found of fatigue cracking. The factors that influenced why the PT blade had partially cracked in the first instance could not be established with absolute certainty. It may be that foreign object impact damage resulted in the formation of an initial first-stage tensile overstress crack (as observed) within the blade root region. Final fracture of the PT blade occurred from tensile overstress, where high power settings were required to achieve the necessary engine performance to accelerate the aircraft for takeoff.

FINDINGS

Context

From the evidence available, the following findings are made with respect to the engine malfunction and subsequent rejected takeoff of VH-UYA, and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

Metallurgical analysis of the fractured power turbine blade revealed that a pre-existing crack had been present at the blade root for a significant period of engine operation prior to the incident malfunction.

During the take-off roll, the left engine of the Saab 340B aircraft malfunctioned due to a fractured stage-four power turbine blade.

Other key findings

Proper management of the engine malfunction and the subsequent decision to reject the takeoff by the flight crew ensured that the passengers, crew and aircraft returned to the apron without any adverse consequences.

SOURCES AND SUBMISSIONS

Sources

The main sources of information included:

- Engine manufacturer: engine teardown report, and a closeout report on the metallurgical aspects to the PT blade failure.
- Aircraft operator: occurrence report.

Submissions

A draft of this report was provided to the Civil Aviation Safety Authority (CASA), the National Transportation Safety Board (NTSB), the engine manufacturer and the aircraft operator.

Submissions were received from the aircraft operator, General Electric and CASA. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.