Boeing 727-230F, OO-DHY

AAIB Bulletin No: 12/2003	Ref: EW/C2002/11/04	Category: 1.1
INCIDENT		
Aircraft Type and Registration:	Boeing 727-230F, OO-DHY	
No & Type of Engines:	3 Pratt & Whitney JT8D-15 turbofan engines	
Year of Manufacture:	1975	
Date & Time (UTC):	19 November 2002 at 0328 hrs	
Location:	East Midlands Airport, Derby	
Type of Flight:	Public Transport (Cargo)	
Persons on Board:	Crew - 3	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to No 1 engine	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	53 years	
Commander's Flying Experience:	14,800 hours (of which 750 were on type)	
	Last 90 days - 90 hours	
	Last 28 days - 32 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The crew reported a loud grinding sound immediately followed by illumination of the 'engine failure' light. They aborted the takeoff at approximately 30 kt and as the thrust levers were closed the commander was aware of resistance within the No 1 thrust lever system. Subsequent examination revealed significant fire damage centred around the underside of No 1 engine, evidence of penetration from inside the engine casing and a fracture of a second stage low pressure (LP) compressor fan blade at the root attachment. There was no evidence of cowl penetration.

Previous incidents, where JT8D second stage LP compressor blade root fractures have caused the release of a blade from the disk, resulted in a manufacturer's Alert Service Bulletin (ASB) No 5729 requiring an ultrasonic and fluorescent penetrant inspection of all second stage fan blade roots. The fan blades from this engine had been inspected in accordance with the ASB but this failure occurred before a re-inspection was required. A blade redesign is available through implementation of a further Service Bulletin (SB). There have been no reported failures to modified blades.

History of the flight

The crew operated an uneventful flight from Frankfurt to East Midlands airport and shut down the aircraft at 0135 hrs. The First Officer (FO) was the designated handling pilot for the next sector and before starting engines the crew obtained the current ATIS and recorded the following information: surface wind 090°/ 08 kt, visibility 300 metres in fog, runway visual range Runway 27, 550 metres, cloud scattered at 100 feet, broken at 200 feet, temperature and dewpoint 4°C and a QNH of 1012 mb. A normal start was conducted for each engine in turn and, since they were operating in icing conditions, engine antice was selected ON prior to taxi[1]. ATC cleared the aircraft to taxi at 0320 hrs and 5 minutes later it was cleared to take off on Runway 27.

In accordance with the published procedures for a takeoff in icing conditions, 70% N1 was set for a period of 15 seconds prior to brake release. The crew later reported that the engine parameters were stable during this period. The brakes were then released and the thrust levers were advanced smoothly to the take-off setting (2·1 engine pressure ratio (EPR) for engines No 1 & 3 and 2·0 EPR for engine No 2). At about the time the engines achieved take-off power the crew heard a noise that they described as a loud grinding sound. This was followed immediately by illumination of the 'engine failure' light. The crew estimated their speed at this time to be about 30 kt.

The crew aborted the takeoff and the commander took control of the aircraft. As he closed the thrust levers the No 1 engine fire warning activated. Resistance within the No 1 thrust lever system however made it difficult for the commander to close fully the No 1 thrust lever. He informed ATC that they were aborting the takeoff with an engine fire, and reminded them that there was dangerous air cargo aboard the aircraft. He then called for the recall items for the engine fire drill. The FO confirmed that the No 1 thrust lever was closed and attempted to position the No 1 engine start lever to the 'CUT OFF' position, however, he was unable to do so because of an apparent restriction to the lever. He continued with the recall actions and pulled the No 1 Fire switch. The engine fire warning light however remained illuminated so he discharged the first fire extinguisher. He commenced timing and selected the bottle transfer switch to arm the second fire extinguisher bottle for use. After 30 sec, with the No 1 engine fire warning light still illuminated, he discharged the second extinguisher. The flight engineer then read aloud the engine fire checklist, including the recall items that had already been actioned. When he called for confirmation that the No 1 engine start lever had been placed to 'CUT OFF' the FO was able to place the lever in the correct position without difficulty.

At this stage the aircraft was approaching taxiway Golf and the No 1 engine fire warning light was still illuminated. As the commander brought the aircraft to a halt the first fire appliance arrived at the aircraft. One of the fire crew contacted the flight crew on 121·6 MHz and informed them that there were flames coming from the front of No 1 engine and they were now applying foam to the area. The commander opened his cockpit window and, although unable to see any signs of fire, called for the evacuation drill. As the flight crew were completing this drill the fire crew informed them that the fire had now been extinguished. After a thorough discussion with the fire crews and ATC the flight crew decided to remain in the aircraft whilst it was towed, with the fire crews in attendance, to a nearby servicing area.

Airfield rescue and fire fighting services

Low Visibility Procedures (LVPs) were in force at East Midlands at the time of the accident. In accordance with these procedures a fully manned fire appliance was positioned at the Mike 3 holding position in order to prevent the unauthorised movement of aircraft or vehicles onto taxiway Alpha. Two other fire appliances were on LVP standby at the fire section and thus already manned. The response of the rescue and fire services was immediate and no problems were encountered in locating the aircraft in the reduced visibility.

The aircraft was loaded with a variety of goods, some of which were classified as dangerous air cargo. The senior fire officer was provided with a copy of the load manifest as he arrived on scene and was thus able to determine rapidly the most effective manner in which to address the situation. The airport

[1] The company operations manual notes that icing conditions exist when the outside air temperature on the ground and for takeoff is 8°C or below and visible moisture in any form is present (such as clouds or fog with visibility of one mile or less, rain, snow sleet and ice crystals)

emergency services, in conjunction with freight operators based at the airfield, have conducted recent exercises involving dangerous air cargo and their effective response on this occasion was due, in part, to lessons learned from those exercises.

Flight recorders

The aircraft was fitted with a Cockpit Voice Recorder (CVR) which recorded flight crew speech and cockpit area microphone sounds on a continuous 30 min loop when electrical power was applied to the aircraft. Unfortunately the circuit breaker was not pulled after the incident and relevant information from the CVR was over-written.

The Flight Data Recorder, a magnetic tape-based Universal Flight Data Recorder (UFDR), recorded only the minimum number of mandatory parameters (airspeed, altitude, normal acceleration, heading and time) on a continuous 25 hour loop. As the accident occurred below 45 knots, the minimum value at which the airspeed parameter registers, there was no useful information to be gained from the recorder.

Engine examination

The Pratt and Whitney JT8D is a two-shaft, low bypass ratio, turbofan engine with a six stage low pressure (LP) compressor. Air enters the engine through the fan inlet case and then passes into the compressor through a two-stage fan after which the airflow is split. The core air continues through the compressor, the remainder flows via discharge vanes into the bypass duct.

No damage was evident externally, however, on opening the No 1 engine cowling there was evidence of significant fire damage centred around the underside of the engine. The fire has resulted in sooting and an oily residue around the outside of the engine casing and damage to wiring. The fuel control unit input rods showed signs of heat damage to the bearings. There was also evidence of penetration from inside the engine casing in the area of the discharge vanes in approximately the 5 o'clock position (viewed from the front). A small piece of debris was found within the cowling. Further examination revealed two penetrations of the engine casing around the 5 and 7 o'clock positions with damage to the oil tank and a ruptured fuel pipe (see Figure 1). Furthermore, some liberated material had penetrated and passed through the core of the engine, with some solidified metal spatter visible in the tail pipe. Visual examination of the LP compressor first stage showed moderate damage to both leading and trailing edges of the stator and rotors.

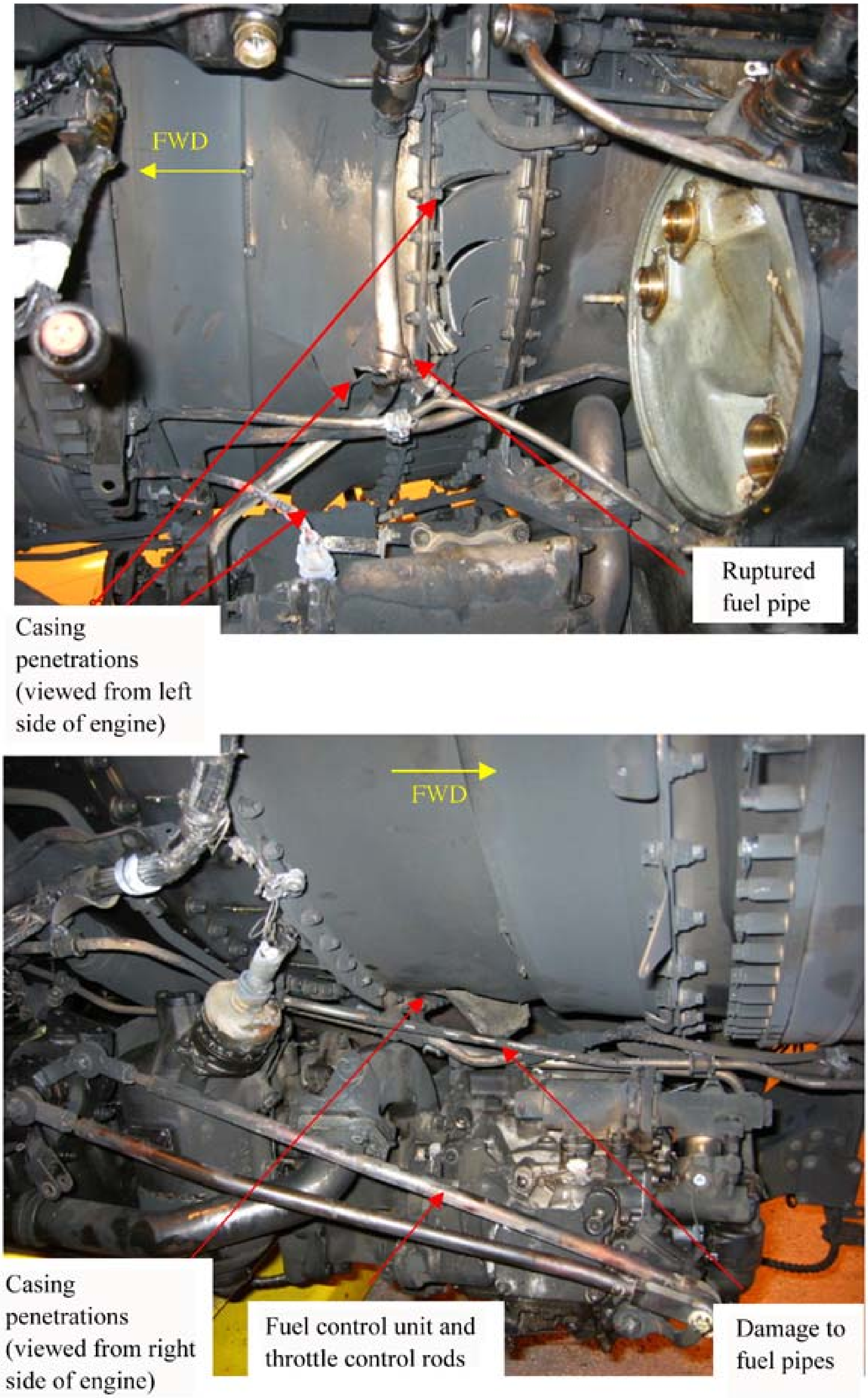

Figure 1 External Engine damage

A boroscope examination and partial engine strip revealed that a second stage LP compressor fan blade had detached. A portion (approximately 2/3 span) of the blade had been retained within the casing. The blade had fractured at the root attachment that consisted of two clevis-type straps. The attachment pin was intact and still in place (see Figure 2).

The penetration marks on the fan case were consistent with fan blade release kinematics. The initial blade tip impact was in the plane of rotation and the impact of the blade root was aft of the plane of rotation. Both impacts tore the containment case. It is probable that no significant material exited through these penetrations as only one piece of blade strap material was recovered from inside the cowling. There was no evidence of cowl penetration.

Second stage assembly removed - casing penetrations at 5-7 o'clock positions

Second stage fan assembly - 'as found' position of detached blade

Figure 2 LP compressor second stage blade failure

The fan discharge vanes were severely damaged in the area of the case rupture and also in the 1 to 3 o'clock position. This appeared to have been caused by the liberated blade being dragged around just prior to final release or just after release. It is likely that the blade tip material exited via this route. There was also some damage to the core inlet guide vanes.

Metallurgical Examination

Visual examination of the blade root fracture surfaces revealed extensive post failure rubbing damage. Where the surfaces had not been destroyed there was evidence indicating ductile overload failure. One of the fractures had a stepped appearance unlike the other three and is therefore considered to be a possible initiation site for the failure, however, post-failure damage had destroyed any corroborative evidence. There was also some twist in the root section indicating that the forces on the blade were sufficient to deform it during the failure. It was also probable that the forward part of the root had failed first, with the rear failing in overload during the twisting.

Previous Incidents

There have been previous incidents where LP compressor second stage blade root fractures have resulted in the release of a blade from the disk. In some cases released fragments have penetrated the engine cowl, damaged or severed fuel lines, and caused engine fires within the cowl. The manufacturer's Alert Service Bulletin (ASB) 5729 Rev 2, dated July 8 1988, identified this problem. At that time there had been a total of 115 fractures of second stage fan blade root attachments. Twenty of these resulted in cowl penetration but with no reports of significant aircraft damage. Nine resulted in fires, all of which were extinguished by means of the engine aircraft fire extinguishing systems.

The blade root fractures were determined to have resulted from propagation of cracks initiated by surface damage, inadequate shot peening, machining marks and material abnormalities. The resulting increase in stress levels serve to initiate cracks that progress through fatigue to blade failure. An ultrasonic and fluorescent penetrant inspection of all second stage fan blade roots was required at each engine's first shop visit after 28 February 1987. A re-inspection was required for any second stage fan rotor removed more than 3,000 cycles since the previous inspection. For those engines where the second stage fan rotor had not been removed, the fan blades must be re-inspected prior to the accumulation of 10,000 cycles since the last inspection. ASB 5729 was mandated in Federal Aviation Administration Airworthiness Directive (FAA AD) 87-14-01 effective from 11 December 1989.

Since the implementation of ASB 5729, there have been a further nine blade fractures on JT8D-15 and -17 engines, two of which resulted in cowl penetrations and three in engine fires.

Service Bulletin (SB)5866, issued on 18 December 1989 and revised on 20 October 1998, provided a more durable second stage fan blade root attachment and a higher life second stage disk. This SB was accepted as terminating action for AD 87-14-01 and released with a compliance level Category 7 (ie to be accomplished when the supply of superceded parts had been depleted). No failures have been reported for the redesigned blade assembly.

Maintenance history

This engine was last overhauled on 14 December 1999. A replacement second stage disk, with the fan blades having been inspected in accordance with AD 87-14-01, was supplied to the overhaul agency by the operator. Since this inspection the engine had accumulated 2,727 hrs and 2,369 cycles.

Discussion

The blade failure resulted in release of fragments that subsequently penetrated the engine casing causing a rupture of the fuel pipe that supplied the engine fuel control unit. The released fuel was subsequently ignited. There was no clear source of ignition, however, and it is possible that metal-to-metal contact within the engine rotating components caused sparks. The crew were initially unable to shut off the fuel supply by closing the No 1 engine start lever to the 'CUT OFF' position due to a restriction, although they were later able to shut the engine down. It is possible, given the position of the mechanical rods transmitting the pilot thrust lever demand to the fuel control unit, that heat from the fire or debris released during the blade failure caused a temporary restriction.

The failure of the second stage fan blade is a continuing airworthiness issue on the JT8D-15 and -17. This failure occurred before the inspection period detailed in ASB 5729. Second stage blade assemblies do not have to be inspected before 3,000 cycles and then only before 10,000 cycles if work is being carried out on that area. This blade failure occurred at 2,369 cycles.

Safety recommendations

There have been no reported failures of the modified blade as detailed in SB 5866, however, the modification is not mandatory and unmodified assemblies continue to be fitted to aircraft. The following safety recommendations are therefore made:

Safety recommendation 2003-113

It is recommended that the FAA, in conjunction with Pratt & Whitney review the inspection and re-inspection period for the LP compressor second stage fan blades as detailed in ASB 5729 and mandated in AD 87-14-01.

Safety recommendation 2003-114

It is recommended that the FAA, in conjunction with Pratt & Whitney, mandate SB 5866 that provides a more durable second stage fan blade root attachment and a higher life second stage disk.