Piper PA-28-181, G-BHZE

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Aircraft Type and Registration:	Piper PA-28-181, G-BHZE
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1978
Date & Time (UTC):	15 March 1998 at 1745 hours
Location:	Near Dundee Airport
Type of Flight:	Pleasure
Persons on Board:	Crew - 2 - Passengers - 1
Injuries:	Crew - Nil - Passengers - Nil
Nature of Damage:	Engine failure and internal damage
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	5,321 hours (of which 2,100 were on type) Last 90 days - 58 hours Last 28 days - Not provided
Information Source:	AAIB Field Investigation

History of the flight

The pilot and two other members of the Turnhouse Flying Club, one of whom was the club Chief Flying Instructor (CFI), decided to to fly from Edinburgh to Glenrothes, via Dundee. Their intention was to land at Glenrothes, change pilots and then return to Edinburgh. However, on approaching Dundee the engine failed, but the propeller continued to rotate. The CFI took control and declared a MAYDAY, advising Leuchars ATC of the engine failure. He then managed to make a successful forced landing on Runway 28 at Dundee Airport from where he advised Leuchars ATC that they had landed safely, before contacting Edinburgh ATC and the flying club.

Examination of the engine

Initial examination of the engine found that the No 3 cylinder valve rocker area exhibited damage and the No 3 exhaust valve was not visible. The engine was removed and sent for repair, during which it was found that the No 3 exhaust valve had broken into two parts, both of which were found inside the

upper cylinder. In addition, there was massive damage to the piston. The crown area of the piston had suffered severe impact damage from repeated contact with the exhaust valve before the top of the piston, above the gudgeon pin location, had detached and jammed in the cylinder, trapping the broken valve parts. The lower part of the piston had broken into a large number of small fragments which were found distributed throughout the engine. There was serious damage to the camshaft lobes, and several cam followers had broken up. There was also a marked degree of bending of the No 3 exhaust valve pushrod and tube.

Metallurgical examination

Metallurgical examination of the broken parts and associated debris determined that the damage to the camshaft and followers was secondary. The No 3 cylinder exhaust valve had not jammed in its guide, although the guide had migrated and broken up. The valve stem retaining collets had broken up, but parts of both collets were recovered and these showed evidence of having been poorly seated. The valve springs had been released; the lower valve spring seat was in several pieces and the upper spring seat, which was of a 'top hat' section and which bore against the collets, had lost its inner flange. Debris was found which was identified as some of the missing parts of this inner flange.

Examination of the fractured surfaces of the upper seat fragments showed that they had suffered repeated impact damage after fracture had occurred, but that there was some evidence of corrosion on the fractures. There was also an associated radial crack which, when opened up, was found to be discoloured and appeared to have been present for some time. Microscopic examination also showed that the material was structurally coarse and contained bands of some form of segregation. Further work showed that the valve seat had been machined from rolled bar and surface hardened. This method of manufacture results in the grain of the microstructure running in a direction which is not ideal, although it is probably adequate for the intended task. The core microstructure was coarse grained and contained a large number of stringers of manganese sulphide. It had been manufactured from a free machining steel with a high sulphur content. In addition, considerable wear of the seat was evident. The remaining exhaust valve seats from this engine, and several from other similar engines, were compared and all were observed to have similar microstructure, but none of these valve seats were as worn as the subject part.

Engine maintenance

Examination of the aircraft logbooks showed that the engine had completed 644 hours since overhaul in July 1995, when it had been 'zero-lifed' and fitted to G-BHZE. It had previously completed 2,371 hours in another aircraft before being removed in April 1993.

At the last engine overhaul in July 1995, both visual and magnetic particle inspection of the valve spring seats had been required and was carried out. However, no cracking was detected and the spring seats were therefore refitted to this engine. The overhaul agency nevertheless reported that such parts had been rejected frequently for cracking found during the magnetic particle inspection. It was not possible to determine the age of the failed valve spring seat.

These parts are small and therefore rather difficult to inspect. The apparent rejection rate for such cracking, where identified, combined with the skill level required for the associated inspections suggested that it would be prudent to renew such valve spring seats when related engines are 'zero-life' overhauled, particularly in view of the potential consequences of later spring seat failure in service, as clearly demonstrated by this massive engine failure.

Engine failure sequence

It was concluded that the engine failure had occurred due to detachment of the No 3 exhaust valve spring upper seat inner flange which had allowed the exhaust valve to drop into the No 3 cylinder, causing destruction of the No 3 piston and breakage of the exhaust valve due to repeated contact between the piston and the exhaust valve. Because of the post-fracture damage, it was not possible to positively identify the mechanism responsible for the detachment of the inner flange, however the poor seating of the collets and the material quality of the spring seat were factors. The metallurgical report also concluded that the cracking of the seat had existed prior to the overhaul, and that the corrosion had occurred during the period when the engine had not been in use (ie April 1993 to July 1995).

Service Bulletin 240P

Textron Lycoming Service Bulletin 240P, dated May 4 1998, addresses the subject of mandatory replacement of parts during normal overhaul of all Textron-Lycoming reciprocating (aircraft) engines, and lists the parts which must be replaced regardless of their condition; other parts are only replaced as their condition dictates. This list does not include the exhaust valve upper spring seats, which are 'on condition' items.

Safety recommendation

In view of these findings arising from this investigation, the following Safety Recommendation is made:

98-54 In order to reduce the possibility of cracking and failure of upper valve spring seats on Textron-Lycoming reciprocating engines, and associated massive secondary engine damage due to valve/piston contact, the FAA should require the mandatory renewal of all spring seats, when such engines are overhauled to 'zero-life', through manufacturer's amendment of Textron-Lycoming Service Bulletin 240P.