AAIB Bulletin No: 2/2005 **Ref: EW/C2003/08/35** **Category: 1.3**

Aircraft Type and Registration:	Piper PA-28R-200, G-BHIR
No & Type of Engines:	1 Avco Lycoming IO-360-C1C piston engine
Year of Manufacture:	1969
Date & Time (UTC):	21 August 2003 at 1315 hrs
Location:	Near Tatenhill Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Substantially damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	654 hours (of which 230 hours were on type) Last 90 days - 9 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB inquiries

Synopsis

A sudden loss of engine power shortly after takeoff forced the pilot to land the aircraft in a field. The landing was made with the landing gear retracted but the only available field was short and the aircraft over-ran and collided with trees, tearing off both wings and injuring the pilot. The power loss was caused by release of one of the engine connecting rods from the crankshaft due to fracturing of the big-end bolts. One of the bolts showed signs of extensive low-cycle fatigue cracking, consistent with the nut having been loose and it was possible that the nuts had not been adequately torque tightened during the last engine overhaul. The available evidence however, was limited by component damage and did not allow the cause of the engine failure to be positively determined.

History of flight

The aircraft, which was owned and operated by a flying group, had been at Tatenhill Airfield for maintenance work on the cockpit instrumentation. The pilot took-off from the airfield

(450 feet amsl) in good weather conditions at around 1410 hrs, with the intention of returning to the aircraft's base at Liverpool. In accordance with normal practice he reduced power at approximately 400 feet agl to the climb setting of 25 inches manifold pressure and 2,500 RPM. A short time later, at a height of approximately 850 feet agl, the engine made a rumbling noise and suddenly lost power. The pilot selected the gliding attitude, switched to the other fuel tank and checked the magneto switches but the engine did not restart. Oil then began to deposit onto the windscreen and the pilot made a MAYDAY radio call and attempted to locate a suitable field for a forced landing.

The pilot's distress call was heard by the crew of a second aircraft that had taken off from Tatenhill shortly before G-BHIR. The commander, aware that the A/G Radio at the airfield was unmanned, attempted to contact the London Information Distress & Diversion Cell; he was unable to make contact but a message was relayed by another aircraft. The crew of the second aircraft then began to search for G-BHIR.

When at around 550 feet agl, G-BHIR's pilot spotted a long field and headed for it. However, as he approached the field he saw that it was obstructed by transmission lines crossing the landing threshold end and turned left towards a second, shorter field, which was the only available alternative. He opted to leave the landing gear retracted to reduce the risk of pitching inverted on landing and had previously unlatched the cabin door. After touchdown, the aircraft slid across the ground on its belly before encountering a copse near the field boundary and coming to a halt. At this point the pilot was aware of an injury to his left shoulder, apparently due to impact with the control yoke.

The pilot exited the aircraft and phoned the emergency services, passing his position obtained from his Global Positioning System. A Police helicopter and an air ambulance helicopter were dispatched to attend the scene. The aircraft was largely hidden by the trees so the pilot walked into the centre of the field to enable the helicopter crews to locate him. He was later diagnosed with a fractured collar bone.

Accident site

Information on the accident site was obtained from the pilot's report, from an Engineer from a local aircraft maintenance company who assisted with recovery of the aircraft and from a subsequent site visit by the AAIB. The Staffordshire Police supplied a plot of the ground marks and wreckage distribution.

The evidence showed that G-BHIR had landed on an easterly track in a field measuring approximately 300 metres in the landing direction. In the area of the touchdown the ground, which was generally firm and covered with short grass, sloped gently downwards in the direction of landing.

The ground markings and aircraft damage characteristics indicated that the touchdown had been gentle, with the landing gear retracted, and that the aircraft had initially skipped. Markings showed that the propeller had been turning. Approximately 155 metres after initial touchdown the aircraft entered a small wood at the field boundary; the fuselage passed between two substantial trees but the wings then struck the trees and were both torn off. The aircraft came to rest very shortly afterwards, with the forward fuselage positioned above a stream and just short of a number of large trees. There was no fire.

Aircraft examination

The engineer who attended the site found that there was engine oil deposited on the aircraft's windscreen and fin leading edge. Two pieces of the engine crankcase were lying in the field a short distance before the start of the aircraft touchdown markings. The engine was removed and strip examined under AAIB supervision.

The Avco Lycoming IO-360 is a four-cylinder, horizontally-opposed reciprocating engine with a rated maximum power output of 200 shp at 2,700 RPM. Each connecting rod is attached to the crankshaft by a split, plain bearing retained by a bearing cap. The assembly is secured by two bolts, each passing through integral bosses formed on the connecting rod and the cap and retained by a nut. The nuts are not split-pined or otherwise positively locked but are meant to be retained by correct torque loading. It is intended that this is obtained on assembly by tightening the nut to achieve the required stretch in the bolt, which is designed to have an accurate unstretched length. The nut is initially tightened to 35 lb-ft torque and the torque progressively increased while checking the bolt length against a gauge. If the required stretched length is not obtainable with a maximum torque of 55 lb-ft the bolt should be rejected.

Examination of the engine found that the No 2 connecting rod big-end had disconnected from the crankshaft. The connecting rod had suffered severe impact damage and an approximately 6 x 8 inch hole had been punched in the upper left part of the crankcase. Both halves of the crankcase had fractured and the other internal components in the region of the No 2 cylinder had been severely battered and deformed. The damage was fully consistent with the effects of impact by the No 2 connecting rod while the engine had been turning and there was no evidence that any other malfunction had occurred.

The cap from the No 2 connecting rod was not recovered and it appeared likely that it had been ejected when the engine failure occurred. One big-end bolt was recovered from the engine, fractured roughly in half, with the thread generally intact but with the nut absent. Part of a nut was also found, severely impact damaged. Neither the bolt nor the nut showed signs of in-service damage to the threads. A portion of the second bolt, consisting of the head and upper shank, was

found on site in the stream. It had suffered severe machining damage and showed signs of associated over-temperature effects; markings indicated that this had probably been caused by repeated contact with the No 2 big-end components after the bolt portion had detached, migrated and become embedded in the crankcase. Both bolts carried the part number 'SL75060 FAA-PMA'.

Detailed examination, by a materials specialist, found that evidence indicating the mode of fracture of the bolts had generally been obliterated by heavy mechanical damage to the fracture surfaces. However, features of the least damaged fracture face indicated that the separation had resulted from a fatigue mechanism and that this had involved high tensile stress over a very low number of cycles. This was consistent with the effects of engine operation with the bolt nut inadequately torque tightened. The big-end bolts for No 3 and No 4 connecting rods were found to be adequately torque-tightened (between 50-55 lb-ft) but substantial damage to the No 2 big-end cap and bolts prevented meaningful checks of their tightening torques.

Aircraft background

The engine had been repaired in late 2002 after metal debris had been found in the engine oil filter. The crankshaft had been replaced at this point. Following the repair the engine had accumulated approximately 115 flying hours at the time of the accident.

Discussion

The engine disruption and sudden loss of power had been caused by the release of the No 2 connecting rod from the crankshaft as the result of separation of the big-end cap from the connecting rod. A number of the relevant parts of the big-end assembly were not recovered, probably having been ejected through the hole in the crankcase in flight, and the parts of the big-end bolts and nuts that were recovered had been severely damaged. However, there was clear evidence that at least one of the bolts had suffered extensive low-cycle fatigue cracking before fracturing and the features of the fatigue were consistent with the nut having been loose while the engine had been operating. It was possible that the failure had resulted from inadequate torque tightening of the nut at the last engine overhaul but, in the absence of some of the parts, there was insufficient evidence to positively determine the cause.