Piper PA-23-160 Apache, G-ARJU, 10 November 1995

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Aircraft Type and Registration: Piper PA-23-160 Apache, G-ARJU

No & Type of Engines:2 Lycoming O-320-B3B piston engines

Year of Manufacture:1961

Date & Time (UTC):10 November 1995 at 1530 hrs

Location:3 miles west of Clacton

Type of Flight: Private (Training)

Persons on Board: Crew - 2 Passengers - None

Injuries: Crew - None Passengers - N/A

Nature of Damage: No 3 cylinder connecting rod failure

Commander's Licence: Commercial Pilot's Licence

Commander's Age:34 years

Commander's Flying Experience:7950 hours (of which 112 were on type)

Last 90 days - 169 hours

Last 28 days - 81 hours

Information Source: Aircraft Accident Report Form submittedby the pilot and further enquiries by the AAIB

The aircraft was being used for training during which flight underasymmetric power conditions was to be practised. The studenthad just completed an exercise with the left engine throttledback when, almost immediately after normal flight had been resumed,the aircraft suddenly started to vibrate severely. The instructorobserved that all engine indications appeared normal, and throttlingback of each engine in turn did not appear to influence the vibrationlevel.

The student, who had retained control, noticed that he was havingto apply some left rudder to keep the aircraft straight and level. In the absence of any clear indication of distress associatedwith the right engine, and because they were relatively near theirbase airfield, the instructor decided to keep both engines runningand to land as soon as possible. The return flight and landingwere uneventful and after taxying back to the maintenance hangar,with the severe vibration persisting, the engines were shut downand the symptoms reported to the engineer.

The right engine was subsequently sent for strip examination duringwhich it was found that the No 3 cylinder connecting rod big-endhad suffered failure of both its clamping bolts and the connectingrod itself had severed about halfway along its length. The fragmentsof this connecting rod and its big-end bolts were all recoveredfrom within the engine. There were no parts of the engine whichhad suffered any damage which might have been consistent withpoor lubrication.

A metallurgical examination was conducted on all of the big-endnuts and bolts from the engine. The associated steels of thenuts and bolts, including those which had failed, were found tocomply with the correct material specifications.

The two failed bolts from the No 3 big-end exhibited quite differentcharacteristics. One had failed entirely as a result of bendingoverload and the associated nut had separated from its thread. The last two threads from within the nut had been 'stripped'and there was metal adhering to the end of the bolt threads.The pressure face of the nut, and the area of the big-end capwith which it had been in contact, showed clear evidence of 'hammering'due to looseness whilst the engine had been running. Additionally,whereas none of the other big-end nuts from this engine, includingthe second one from this failed big-end, showed significant lossof the copper plating from their contact faces, most of the copperplating had been worn off the contact face of this nut. In addition,the pressure face on the machined pad, on the connecting rod itself,from under this bolt head had also been severely 'hammered' andthe locating corners of the bolt head had heavily scored the sideface of the pad (see Fig 3). The bolt thread, below the depositedmetal, also showed slight evidence of hammering wear.

The second bolt from this big-end had suffered a high strain fatiguefailure over most of its cross section, with final separationin tensile overload (see Fig 2). The fatigue had initiated fromthe side which had been nearer to the crankpin, and had occurredover a very short period of engine operation. The nut had beenretained on the thread, after bolt separation, and although ithad run back a little from its expected position when fully tightened,there was no evidence of hammering wear on the threads. Therewas also very little evidence of the bolt head hammering on themachined pad on the connecting rod shoulder (see Fig 4). Althoughthere was some evidence of scoring by the bolt head on the sideface of the pad, it was much lighter than that caused by the otherbolt.

Examination of the clamped faces between the big-end cap and theconnecting rod revealed that the faces on the side with the boltwhich had failed in bending showed only light evidence of relativemovement, whereas those on the side with the fatigued bolt wereheavily polished.

The damage observed was consistent with the nut on the bolt whichhad failed in bending having worked loose and having run backalong its thread. This would have overloaded the second bolt,inducing the associated high strain fatigue and causing polishingbetween the securely clamped faces of the big-end of the rod andthe cap (See Figs 1, 5 & 6).

The engine had been subjected to a shock load inspection, followinga propeller ground strike, some 230 flying hours before this failure. During this inspection, all the big-end bolts and nuts had beenreplaced and, although the associated parts had not been suppliedby the engine manufacturer, they met the appropriate materialspecifications. Information from the manufacturer indicated thata small number of engines have suffered from big-end bolts becomingloose some considerable time (ie up to about 1000 hours) afteroverhaul. The manufacturer's investigations of many of theseinstances has not revealed any evidence that these could havebeen caused by any reason other than that the big-end bolts hadnot been tightened in such a way as to achieve and retain thedesired clamping force. The engine design specification doesnot require mechanical locking of such big-end bolts, eg by tabwashers, which used to be general practice on all piston enginesof general

aviation aircraft, before such manufacturers adoptedtorquing of big-end bolts as the sole means of assuring security.