

Beech M35 Bonanza, G-ATSR

AAIB Bulletin No: 4/2003 Ref: EW/C2002/05/08

Category: 1.3

Aircraft Type and Registration:	Beech M35 Bonanza, G-ATSR	
No & Type of Engines:	1 Continental Motors Corp IO-470-C piston engine	
Year of Manufacture:	1959	
Date & Time (UTC):	19 May 2002 at 1253 hrs	
Location:	On beach, north-west of Worthing Pier, Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 2
Injuries:	Crew - 1 (Minor)	Passengers - 2 (Minor)
Nature of Damage:	Damage to engine, propeller, airframe and landing gear	
Commander's Licence:	Private Pilots Licence	
Commander's Age:	32 years	
Commander's Flying Experience:	241 hours (of which 7 were on type)	
	Last 90 days - 14 hours	
	Last 28 days - 10 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB investigation	

Synopsis

Following a catastrophic engine failure, shortly after takeoff from Shoreham, the pilot executed a skilful forced landing onto Worthing beach to the north-west of Worthing Pier, despite oil on the windscreen and smoke in the cockpit. The occupants of the aircraft suffered only minor injuries and no person on the beach was injured.

A detailed examination of the engine revealed that the No 4 big-end bearing had failed, releasing the connecting rod, and this had resulted in severe localised damage within the engine. There was clear evidence of severe heat damage, resulting from a lack of lubrication in the region of the No 4 big-end bearing, and both associated bearing cap bolts exhibited evidence of fatigue cracking, although these cracks were not assessed as being causal to the failure. A significant quantity of oil

remained within the engine, and no other areas appeared to have suffered from the effects of a lack of lubrication. Due to the severity of damage, the origin of the failure was not established.

History of flight

The pilot and his two passengers had arrived at Shoreham Airport from Le Touquet earlier that day and were planning to continue on to Kemble, where the aircraft was based. The weather conditions were: wind 210°/10 kt and visibility 10 km, with nil significant weather. The pre-flight checks were completed with no abnormal indications and the aircraft departed from Runway 21. As the aircraft reached 1,000 feet in the climb, there was a loud bang and the windscreen quickly became covered with a substantial amount of oil. The pilot lowered the nose and put out a MAYDAY call to Shoreham. Shortly thereafter the cabin began to fill with smoke and so the pilot reached across to the right side of the aircraft to unlatch and open the cabin door. This proved effective in helping to clear the smoke and he instructed the passenger in the front seat to hold the door ajar.

Faced with a total loss of power, the pilot trimmed the aircraft for 80 kt and searched for a suitable place to land. His options for landing to the right were severely limited by a built-up area and he initially considered ditching the aircraft in the sea. He then observed an unoccupied stretch of Worthing beach, which he judged to be a preferable option, and so selected full flap and gear down prior to turning off the fuel and electrical services. The approach was flown slightly fast to allow the option of trading speed for height late in the approach so that, if necessary, the aircraft could be landed in the shallow water adjacent to the shingle beach. Just prior to touchdown the pilot observed a shingle moving vehicle in the distance and so was reluctant to hold off during the landing. He placed the nose gear onto the shingle and pulled the aircraft back onto its main gear to slow down, maintaining directional control for as long as possible using the rudder. As the aircraft came to a stop a short distance to the west of Worthing Pier, it spun round to the right and the left wing dropped and struck the shingle. The occupants received only minor injuries and were able to exit the aircraft unassisted. Damage was limited to the undercarriage, left wing tip, engine and propeller.

Engine maintenance history

The engine, serial number 87027-1-H, had been previously overhauled and was installed in this particular aircraft in June 1989. At the time of the accident it had completed approximately 531 hours since that overhaul. The engine log book showed that the most recent Annual Inspection was completed on the aircraft on 15 January 2002 at 499.75 engine hours and that the engine was removed during this inspection for the cylinders to be overhauled. It was reassembled with new piston rings, valves and valve guides, prior to being reinstalled in the aircraft and the oil and oil filter were also replaced at this time. Entries in the log book indicated that the aircraft had not flown between 14 January 2001 and the time of the Annual Check in January 2002, and it could not be established if the engine had been run, or inhibited, during this time.

A plastic bag was found inside the log book and this contained a piece of oily paper towel, which itself contained numerous small, shiny, silver fragments of metal, Figure 1 (*jpg 33kb*). These fragments appeared to be similar to the metal used in engine main and big-end bearing shells. There was no textual reference to these fragments in the log book and extensive enquiries failed to shed any light on their origin.

The aircraft was purchased by its new owners, a syndicate, shortly after completion of the Annual Check and they had flown it for approximately 31 hours prior to the accident. The pilot reported

that the oil quantity and oil pressure were satisfactory when checked prior to departure on the accident flight but that the aircraft had experienced oil pressure indication problems on a previous flight. When investigated by a maintenance organisation, it was reported that there was probably air in the oil pressure gauge and that it required bleeding. After completion of this work the oil pressure indication returned to normal and the aircraft then completed several flights prior to the accident with no reported problems.

Engine strip examination

The engine was initially examined prior to removal from the aircraft. A hole was visible in the top of the left side of the crankcase, in the plane of the No 4 piston, and it was apparent that this hole had been produced by the No 4 connecting rod flailing around inside the crankcase. Oil forced out of the crankcase had escaped through the gaps in the engine cowl and contaminated the windscreen. Fragments of the No 4 connecting rod bearing cap were ejected through the hole and were found lying on the cooling baffles between the cylinders. There was a significant quantity of oil remaining in the sump and a sample of this was taken for analysis.

The engine was stripped by an independent overhaul shop under the supervision of the AAIB. The No 4 piston was jammed in the crankcase and this required machining open to facilitate its removal. The No 3 piston was jammed in its cylinder due to damage to the base of the cylinder and the piston skirt caused by the flailing No 4 connecting rod. The inside of both crankcase halves exhibited multiple impact marks for the same reason. The lower end of the No 4 connecting rod was severely distorted and blackened from overheating, Figure 2 (*jpg 56kb*), consistent with heat transfer due to friction caused by insufficient lubrication of the bearing. The bearing end cap had split in half and showed similar signs of overheating. The two No 4 bearing end cap bolts were recovered and both had fractured at the waisted section near the centre of each bolt. The crankshaft itself was undamaged, with the exception of the No 4 big-end journal, which was very rough and blackened.

The big-end journals are supplied with oil via a cross-drilled hole from the adjacent crankshaft main bearing. The oil-way to the No 4 big-end was found to be free from obstruction, Figure 3, and the adjacent crankshaft main bearing exhibited no signs of distress. This suggested that there had been no restriction of the oil supply to the crankshaft main bearing and that the oil starvation had been local to the No 4 big-end. The crankshaft main and big-end bearings from the other locations showed evidence of scoring, and appeared slightly darker than would normally have been expected, but these effects were believed to be consequential to the primary failure.

A large amount of metallic debris was found in the sump, including numerous small slivers of metal from the No 4 big-end bearing, but no significant debris was found that could have originated from outside the engine. No failures were observed in any of the oil system components and, with the exception of the No 4 big-end bearing, there was no evidence of lack of lubrication within the engine.

Oil analysis

The analysis of the oil sample from the sump showed that it was consistent with an SAE 50 grade mineral oil. The water content, Total Acid Number and lead content were somewhat higher than typical values for used oil from engines operated on leaded gasoline. The reason for these high values was not clear as, according to the engine logbook, the oil had been replaced during the Annual Check approximately 31 flying hours prior to the accident. Elemental analysis of the oil

showed evidence of wear to steel, aluminium and copper/soft metal bearing material, and this was consistent with the damage associated with the No 4 big-end failure.

Metallurgical examination

The crankshaft, the No 4 connecting rod and its associated components were subjected to metallurgical examination. Microstructure changes to the crankshaft No 4 big-end journal material showed that it had been exposed to temperatures in excess of 700°C, as a result of frictional heat generated by the lack of lubrication. Hardness checks of the connecting rod, fragments of end cap and the end cap bolts showed that they had all become softened where they had been exposed to the greatest effects of the heating.

Microscopic examination of the fracture surfaces of the end cap bolts showed the presence of fatigue cracks on either side of both bolts in the region where they were waisted, with a fibrous central region between these cracks. The nature of the fatigue cracking was indicative of the bolts having been subjected to reverse bending loads, culminating in ductile overload failure of their central regions. Whilst the exact mechanism that had produced these failures was not determined, it was agreed that there was no indication of any pre-existing defects in either bolt. The possibility that the nuts on the end cap bolts may not have been sufficiently torque tightened was considered. In such cases, fretting is often evident on the mating faces between the connecting rod and the end cap. The extent of the damage to these components, however, was such that these surfaces had been completely obliterated and therefore no conclusions could be reached in this respect.

Discussion

The pilot displayed a considerable degree of airmanship in managing the combined problems of the engine failure, reduced cockpit visibility due to smoke in the cabin, a restricted external view due to oil on the windscreen, and the limited availability of sites to execute a forced landing. By concentrating first on flying the aircraft and trimming for best glide speed, he was able to quickly contain the immediate problem of the engine failure, which allowed him to focus on the next priority of searching for a suitable landing site. By employing the front passenger to hold open the cabin door, he was able to limit the amount of smoke entering the cabin to the point that it did not interfere with his ability to continue to fly the aircraft. This allowed him to concentrate on planning the approach and landing, which he successfully completed with minimal injuries to the occupants whilst avoiding any bystanders.

The engine failure occurred as a result of the failure of the No 4 piston connecting rod big-end bearing. From the available evidence, it was not clear whether the bearing itself had initiated the failure, or if another problem had precipitated the bearing failure. Whilst the substantial damage to the components precluded any definitive diagnosis of the failure initiation, it was evident that effects of any such problem had resulted in the No 4 big-end bearing being starved of oil. The fact that the adjacent crankshaft main bearing, from which the No 4 big-end received its oil supply, was undamaged, suggested that there had not been a general restriction of the oil supply to the crankshaft bearings. The engine had continued to run until the No 4 big-end bearing failed due to the frictional heat generated. The resulting increased clearance would have caused the connecting rod bolts to be subjected to hammering and this would have been compounded by fact that the rod bolts themselves had been weakened by the effects of heat. The failure of the rod bolts in a fatigue mode of cracking might suggest this as an initiating factor, but the fact that a reverse bending mechanism was indicated, rather than cyclic axial tension, tends to suggest otherwise. It is more likely that their failure was as a consequence of other events.

The presence of what appeared to be slivers of bearing material contained in the aircraft log book is a concern, given the lack of any reference to them in this book. If these slivers had been discovered during a previous oil change, and had come from a deteriorating bearing, then appropriate action taken at the time might have prevented the engine failure.

Conclusions

The engine failure was caused by a failure of the No 4 piston connecting rod big-end due to localised oil starvation. It was not possible to determine the initiating event given the severity of the damage to the components, but the balance of evidence suggested that the primary problem may have been associated with the big-end bearing shells.

The engine failure after takeoff, and the associated complications of smoke in the cabin and oil on the windscreen, were well managed by the pilot. Although engine failure, leading to total or partial loss of power, is fortunately a rare event, it is an ever present risk and may occur for a variety of reasons other than mechanical failure, including, for example, carburettor icing. This accident reinforces the need for pilots to be mindful of the possibility of an engine failure at critical points in a flight, and to ensure that their experience and competency of practised forced landings remains current.