RAF 2000, G-BWAE

AAIB Bulletin No: 2/2004	Ref: EW/C2003/02/03	Category: 1.4
Aircraft Type and Registration:	RAF 2000, G-BWAE	
No & Type of Engines:	1 Subaru EA82 piston engine	
Year of Manufacture:	1995	
Date & Time (UTC):	5 February 2003 at 1500 hrs	
Location:	Hall Farm landing strip near Lichfield, Staffordshire	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to rotor blades, nosewheel and underside of cockpit	
Commander's Licence:	Private Pilot's Licence (Gyroplanes) with instructor rating	
Commander's Age:	54 years	
Commander's Flying Experience:	1,470 hours (of which 252 were on type)	
	Last 90 days - 6 hours	
	Last 28 days - 3 hours	
Information Source:	AAIB Field Investigation	

History of the flight

The aircraft, built from a kit by its previous owner, had suffered at least one roll over accident and the rotor blades had been replaced twice before it was sold to the pilot. He fitted new parts including further new rotor blades and the aircraft subsequently completed about 60 hours of flying without incident.

Not long before the accident flight, chord-wise cracks had been found in both of the composite main rotor blades and the aircraft had been grounded. The AAIB commissioned a detailed material examination of the cracks as they were thought to be related to a fatal accident involving another RAF 2000. The examination indicated that the cracks, that were not relevant to the earlier fatal accident, were a result of 'lay-up' issues which were subsequently taken up by the CAA with the kit manufacturer.

A further set of new blades for G-BWAE were received from the manufacturer, and these were fitted. A new, taller teeter block was also obtained. While attempting to fit this however, some damage was found to bolts in the assembly. This was considered to have been damage undetected after the roll over accident and consequently a complete new gimbal head was procured. Much effort was expended carefully aligning the new rotor hub bar and gimbal head, in order to achieve low vibration levels. Ultimately the gimbal head was successfully fitted to the aircraft and signed off by a PFA inspector who was also a gyroplane instructor.

The aircraft was inspected on the morning of the accident and issued with a flight release note by the PFA inspector. The inspector then carried out two solo flights, in calm wind conditions, during which the aircraft performed well with no undue vibration. The third flight was flown dual with the inspector being accompanied by the owner.

A handling check, carried out after a normal takeoff and climb to 1,500 feet, showed no problems and the flight was continued as a circuit training detail at a local microlight airfield. The aircraft landed back on its home grass strip without incident 1 hour and 15 minutes later. The aircraft was then refuelled and prepared for a further flight.

After the usual checks, including control checks, the aircraft was positioned for takeoff, the pre-rotator engaged and the takeoff commenced. The aircraft lifted into a level attitude and the owner, who was handling, gently eased the stick forward to increase airspeed. As expected the aircraft maintained a level attitude as the speed increased until, at an estimated height of approximately 10 feet, it developed a marked nose down attitude and rolled slightly right. The instructor felt the pilot compensate but considered, from the attitude of the aircraft, that he had not been positive enough with the controls, and so pulled firmly and fully aft. The aircraft did not respond and hit the ground hard breaking off the nose gear and coming to rest upright with the engine still running. The aircraft was shut down and the occupants vacated the cockpit without injury. The pilot and instructor both felt that there had been no response to the controls, and that the stick had moved without the usual resistance from normal control forces.

Aircraft post-accident inspection

The rotor blades had struck the ground during the impact causing damage to the blades and the mast. Inspection showed that the rotor blades were grossly delaminated and that there had been a fracture of one control rod eye end in the rotor control system. The rotor control system was otherwise complete and, although the mast was damaged, could still be functioned. A visual examination of the fractured eye end showed it to have plastically deformed in bending before final fracture, indicating overload conditions. Attention was therefore focussed on the delaminated blades.

Rotor blades

The blades were examined using ultrasonic testing, a scanning electron microscope, peel testing and various fractography techniques. While some issues concerning the lay up of the blades were raised, the subsequent report concluded that the damage to the blades had occurred due to ground impact and not during flight.

In the light of this, consideration of the handling issues was made by representatives of the CAA, PFA and the AAIB. The consensus was that the accident was not a result of weather, handling or stability issues. Therefore the fractured eye end was re-examined by a metallurgist.

Control rod

The metallurgical report found that the eye end of the control rod had fractured by overload in bending, as previously thought. The surface appearance and distortion of the fitting suggested, at the most, a few load cycles to final fracture. The eye end was a commercial part closely resembling an aerospace quality component in appearance. The main difference however was that the body of the fitting was manufactured from a free-machining low carbon steel with a tensile strength of around 34 tons/in^2. In an aerospace application, a low alloy steel of around 50-60 tons/in^2 would be expected, however there was no requirement to use an approved part in this application. Furthermore, the steel used had a high concentration of manganese sulphide 'stringers' which were able to significantly further reduce the expected bending strength and stiffness.

Manufacturers information

The aircraft manufacturer examined their files relating to the aircraft, and concluded that the spares purchases, which included rotor and propeller blades, indicated that the aircraft had experienced several mishaps. The manufacturer recommends that after a roll over or any event resulting in a rotor strike 'the gimble head and the entire control system should be inspected and all the control rod ends and other suggested parts replaced'. Neither the manufacturer nor the company UK representative had any record detailing the supply of replacement rod ends for use on G-BWAE. Accordingly, the

manufacturer considered that the rod eye ends may have sustained undetected damage prior to the accident flight.

Conclusion

The most probable explanation of this accident is that forces, generated during the period between the pre-takeoff checks and the loss of control, resulted in the fracture of the eye end of the control rod, due to its reduced strength. Although it is possible that this reduced strength was due to cumulative damage, there was no evidence of fatigue in the fracture. The reduced strength of the eye end may have been due to previous damage, although the metallurgical examination did not suggest this. Therefore, although the cause of this accident cannot be determined with certainty, it remains a possibility that the bending strength of the eye end of the control rod is marginal. The following safety recommendation is therefore made:

Safety Recommendation 2003-130

It is recommended that the CAA and PFA ensure that the 'eye end' fittings of the RAF 2000 rotor head control rods are manufactured from material of a suitable specification to prevent failure during operation within the certified flight envelope.