ACCIDENT

Aircraft Type and Registration:	Cyclone AX2000, G-MZJR	
No & Type of Engines:	1 HKS 700E V3 piston engine	
Year of Manufacture:	1998	
Date & Time (UTC):	24 July 2009 at 1024 hrs	
Location:	Near Shoreham, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Serious)	Passengers - 1 (Minor)
Nature of Damage:	Substantial	
Commander's Licence:	Private Pilot's Licence (Microlight)	
Commander's Age:	44 years	
Commander's Flying Experience:	750 hours (of which 150 were on type) Last 90 days - 20 hours Last 28 days - 4 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was flying at 600 ft agl when the engine suddenly stopped. The pilot chose a small field for a forced landing and landed downwind with a tailwind of 10 to 15 mph. The aircraft landed well into the field and the combination of a late touchdown with a high groundspeed and poor braking action on wet grass caused the aircraft to run on into a substantial wooden fence. Both the pilot and his passenger were injured in the accident.

History of the flight

The flight was planned to cross the English Channel to France, with a view to returning the next day as one of a large number of microlight aircraft taking part in a Bleriot Centenary celebration.

The aircraft was based at Clench Common microlight site, Wiltshire. When the passenger arrived on the morning of the accident the pilot, who was a part-owner of the aircraft, had refuelled it and prepared it for flight. They both ensured that their baggage weight was kept to a minimum. The pilot calculated the takeoff weight as 415 kg. The fuel on board at departure was 45 litres, giving an endurance of more than four hours.

The pilot planned to fly from Clench Common to Headcorn Airfield, Kent, to clear customs before continuing on to Le Touquet, France. Aware that the weather was changeable with rain showers forecast, he planned two possible routes and drew them on his map. The aircraft took off from Clench Common at 0835 hrs and flew in an easterly direction at first, but soon the pilot decided to take the more southerly of the two routes and flew in a south-easterly direction towards a turning point north of Chichester. This route took the aircraft close to Popham Airfield and, while en route, the pilot decided, in view of the prevailing showery conditions, to land there and reassess the weather. The aircraft landed at Popham at 0905 hrs.

The pilot and his passenger spent their time at Popham looking at a radar chart of the weather activity and discussing possible routings. At 0925 the aircraft took off and headed in a north-easterly direction before intercepting the M25 motorway and following it for a time. The pilot then decided that further progress towards Headcorn Airfield was not possible, and turned north-east towards Biggin Hill. He contacted Biggin ATC and arranged to route overhead at 2,000 ft amsl. Once he had passed overhead he descended to 1,100 ft amsl to avoid more showers, and considered where to route next. He had just decided to continue towards Rochester Airfield when, suddenly, the engine stopped. The pilot made an unsuccessful attempt to restart the engine and selected a field for a forced landing. He broadcast a MAYDAY message to Biggin ATC informing them of the problem and that he would be landing in a small field.

When the engine failed the propeller stopped immediately and the aircraft began to descend. The passenger commented that the descent was steep and time appeared short. The pilot lined up on his chosen field, which was rectangular and orientated in an east-west direction, and made an approach crossing low over the fence at the upwind (western) end. The aircraft travelled approximately 400 ft into the field before touching down. The passenger remembered that after the touchdown there seemed to be very little retardation before the aircraft ran into the fence at the far end.

The impact with the fence and a vertically embedded railway sleeper was severe and the pilot was rendered unconscious. The passenger exited the aircraft and, concerned about the possibility of a fire, attempted to help the pilot out. However, he was unable to do so and instead, having some knowledge of first aid, made sure that the pilot was in a safe position and able to breathe.

Biggin Hill ATC made several attempts to call G-MZJR but received no response and asked a training aircraft with an instructor on board to attempt to locate the missing aircraft. The training aircraft soon found the wreckage and circled overhead at the request of ATC in order to enable the Distress and Diversion (D&D) cell of the London Area and Terminal Control Centre to obtain a position fix on the accident site. The emergency services arrived soon afterwards and the pilot, who had sustained a head injury, was subsequently transferred to hospital in an air ambulance helicopter. The passenger, who suffered extensive bruising, was taken by road to a local hospital. He was discharged later the same day and subsequently had a good recollection of events throughout the flight. He was not a qualified pilot but was undergoing training on flex-wing aircraft towards a Private Pilot's Licence (Microlight).

The radio communications between Biggin Hill ATC and the aircraft were recorded and were available to the investigation.

Meteorological conditions

The south of England was subject to a strong westerly airflow with areas of cumulus and cumulonimbus cloud giving rise to heavy rain showers. The surface winds in the area of the accident were from a westerly direction at 10 to 15 kt, the visibility was good away from the rain showers. There had been recent showers in the area of the accident and the surface of the chosen landing field was wet.

Pilot information

The pilot had been flying microlight aircraft for 11 years. He flew regularly and was currently flying a number of different types of aircraft. He had owned this aircraft for a number of years and it was very familiar to him.

Aircraft information

The Cyclone AX2000 is a two-place side-by-side three-axis microlight aircraft. The maximum all up weight is 450 kg. The aircraft has forward-hinged removable doors; they were removed for this flight. There are two fuel tanks providing a maximum capacity of 50 litres. The recommended best glide speed is 45 mph.

The engine manufacturer provides the following advice to pilots in the HKS 700E Operations Manual:

> *'WARNING!*
>
> *This is a non-certified aircraft engine, the possibility of engine failure exists at all times. Do not operate this engine over terrain where a safe, power off landing cannot be performed.'*
>
> *The operating and maintenance instructions supplied with this engine must be followed at all times. Flying any aircraft involves the risk of injury or death, building and maintaining your own aircraft requires great personal responsibility.*

Landing field

When the engine stopped the ground below was undulating, with an elevation between 400 to 500 ft amsl. The general area was part built-up, part woodland and part fields with several major roads and power lines in the vicinity. There were no fields obviously suitable for a forced landing. The pilot's chosen field was level, with a grass surface and measured 150 m from west to east. The grass was approximately 15 cm long and was wet from recent rain. There was a 1 m high wire fence at the western end and a more substantial wooden post and rail fence with a number of vertically embedded old railway sleepers supporting cattle water troughs at the other end. On the southern boundary of the field were telegraph poles carrying power lines and in the adjacent field to the south was a line of pylons running from west to east.

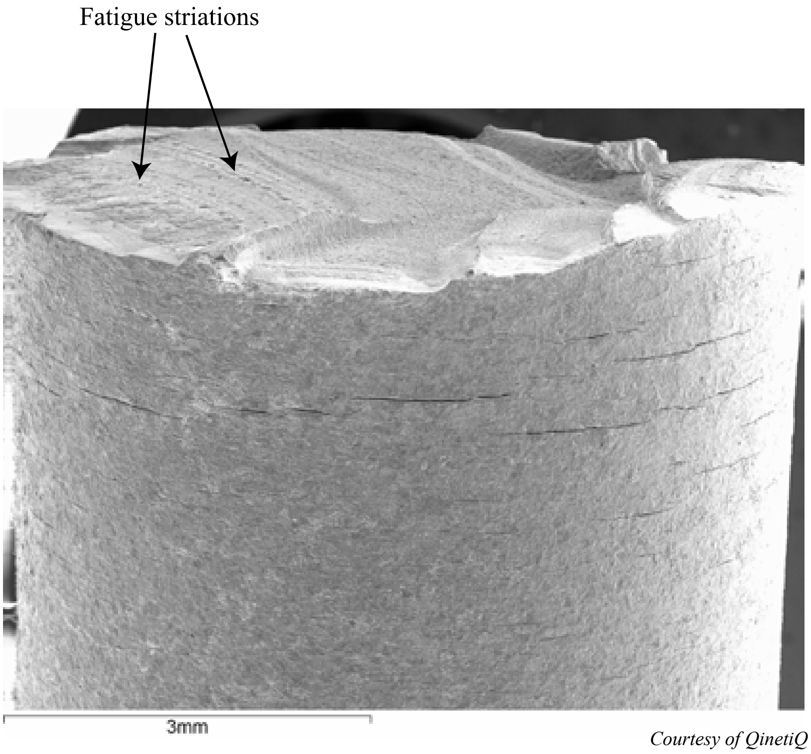
Engineering investigation

Examination of the aircraft at the accident site indicated that the engine had seized due to an internal failure. The engine was taken to the manufacturer's UK agent's facility where, under AAIB supervision, a strip examination was carried out. This revealed that the head of one of the two exhaust valves in the No 1 (right) cylinder had separated from its stem and caused severe disruption and break-up of the piston, which had eventually resulted in the seizure of the engine. The cylinder head, complete with three intact valves and the failed valve stem, was submitted for specialist metallurgical examination.

The valves were cleaned using acetic acid in an ultrasonic bath to remove surface deposits prior to examination in a scanning electron microscope. The examination showed that the failure of the exhaust valve was the result of fatigue that had initiated from multiple origins in the valve stem. Examination of the stem in the region of the failure (Figure 1) highlighted thermally-generated corrosion, which provided the stress concentration to initiate fatigue.

It was noted that the microstructure of the valve material at the points of failure had been altered by the effects of temperature to a condition that was more susceptible to corrosion and hence fatigue initiation. The rate of such changes in microstructure is temperature dependent. Therefore, failure could occur prematurely in these valves if the operating temperature is higher than 'normal'. However, even at 'normal' operating temperatures, it is expected that failure would eventually occur after many hours in service.

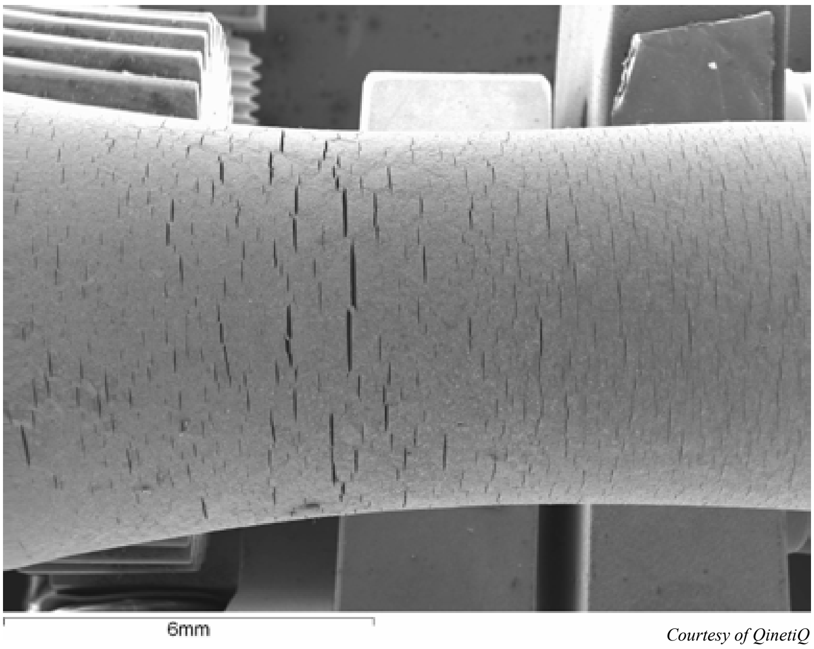
The exhaust valve that had not failed was also examined; numerous cracks were observed in the surface (Figure 2). These also appeared to be fatigue cracks and this valve, if allowed to continue in service, would have failed in the same manner as the fractured valve.



Courtesy of QinetiQ

Figure 1

Failed exhaust valve stem showing secondary fatigue cracks



Courtesy of QinetiQ

Figure 2

Surface cracking on stem of non-failed exhaust valve

Engine history

The engine fitted to this aircraft was an HKS 700E V3, serial number 100202, built in 2000. It is a horizontally-opposed, two-cylinder, four-stroke air-cooled engine with pumped oil for lubrication and cylinder head cooling. Each cylinder has two inlet and two exhaust valves. Following a short period in service the manufacturer became aware of a number of problems which included poor cylinder head cooling and poor oil scavenge performance. The engine was redesigned and given the designation HKS 700E Beta. This redesign included cylinder heads manufactured from a modified casting with a much improved oil system to increase the oil flow and improve cooling. The engine fitted to G-MZJR had the Beta model cylinder heads fitted in December 2002, when it had completed 287 hours since new. In July 2003 the oil system on this particular engine was modified, to an approved one-off modification scheme, to increase the oil flow to improve cooling and thereby maintain the cylinder head temperatures within the limits specified for the V3 and Beta models. At the time of the accident the engine had completed 831 hours since new; the valves had completed 544 hours since they were fitted in 2002. The engine manufacturer replaced engines up to serial number 100300 but a small number of engines, such as the one fitted to G-MZJR, remained in service.

Engine valve service life

The manufacturer's recommended overhaul life for the 700E V3 engine was 300 hours or 5 years and the inlet and exhaust valves had to be replaced at overhaul. In April 2004 the overhaul period for the 700E engines with serial numbers from 100600 was increased to 800 hours or 8 years (HKS 700E Service Letter SL-700-001). In March 2007 the overhaul period for the 700E engines with serial numbers up to 100600 was increased to 500 hours or 5 years (HKS 700E Service Letter SL-700-002). The engine manufacturer stated that neither of these Service Letters applied to the engine fitted to G-MZJR and they were issued in the belief that all engines up to serial number 100300 had been replaced.

The pilot believed that the installation of the Beta cylinder head and the improvement of the lubrication system on the engine fitted to G-MZJR would have improved its longevity and therefore took the decision to extend its service life. This decision was also based on his experience of other, similar four-stroke engine types for which the service life had been successfully increased with only standard regular maintenance.

Analysis

The engine failure was caused by the fracture of an exhaust valve due to a fatigue failure initiated by thermally-generated corrosion. This could occur if the valve had been operating above the material's maximum operating temperature, or for a time in excess of the valves recommended operating life, or a combination of the two. The engine manufacturer recommended that all valves be replaced at overhaul. This particular engine should have been overhauled every 300 hours or 5 years. However, at the time of the accident the valves in the No 1 (right) cylinder had completed 544 operating hours and 6 years 7 months had elapsed since fitment. The pilot, based on his experience with other, similar engine types, and the improved modification state of the engine, considered that an extension of the service life of this engine was justifiable.

The pilot had been altering his route and diverting around areas of rain showers for much of the flight. He had flown overhead Biggin Hill Airport at 2,000 ft amsl, where he could have landed if he had chosen, a few minutes before the engine failure.

When the engine stopped, the aircraft was flying beneath rain showers at an altitude of 1,100 ft amsl. The terrain in the area was between 400 and 500 ft amsl, so the height of the aircraft was about 600 ft agl. When the engine stopped the propeller also stopped, which created additional drag. The result of these factors was that the range of the aircraft was limited and therefore the time available for the pilot to find a suitable landing field was short. The pilot managed the primary task of flying the aircraft and maintaining control as he made an approach into a field. However, the field was short, the surface was wet and the aircraft landed directly downwind. The result was that the aircraft ran on into the fence at a considerable speed, leading to the pilot sustaining a serious injury.

The tailwind was a significant factor in the outcome of the forced landing. The glide speed of the aircraft was 45 mph, thus with a tailwind of 10 to 15 mph the landing speed was increased by some 25% to 30%. The tailwind would also have had the undesirable effect of flattening the trajectory of the final approach, thereby leading to a longer touchdown into the field. This is a factor which may not always be taken into account when considering the suitability of a landing field. The result was that, although the aircraft passed low over the boundary fence, it touched down 400 ft into a field that was only 500 ft long. The combination of a high groundspeed and poor braking effectiveness on the wet grass meant that there was little reduction in speed before the impact with the fence.

Conclusions

Pilots of single-engined aircraft should be aware that an engine failure can occur at any time. A forced landing is more likely to be successful if the aircraft is flown at a height which affords more choices of suitable landing sites, especially in areas of difficult terrain. On this occasion the choice of fields available to the pilot was reduced because he had descended beneath some showers and was passing over relatively high ground.

The engine seizure was precipitated by the failure of an exhaust valve due to thermally-generated fatigue cracking in the valve stem. This was caused by operation of the engine beyond the manufacturer’s recommended engine overhaul life of 300 hours or 5 years.