ACCIDENT

Aircraft Type and Registration:	Speedtwin ST2, G-STDL	
No & Type of Engines:	2 LOM M332B piston engines	
Year of Manufacture:	2007	
Date & Time (UTC):	22 April 2009 at 1515 hrs	
Location:	Near Woodbridge Airfield, Suffolk	
Type of Flight:	Private	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Right and left propellers, right engine cowls, and front fuselage	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	9,600 hours (of which 22 were on type) Last 90 days - 61 hours Last 28 days - 23 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB examination of the propellers	

Synopsis

Whilst in the cruise at 4,000 ft and accelerating towards maximum speed, a loud bang was heard and the right engine began to vibrate, followed by some smoke and a smell of hot oil. The pilot shut down the right engine and selected the propeller switch to the feather position. However, the propeller failed to feather and the engine continued to rotate. Control of the aircraft was maintained with the left engine but the right engine vibration remained severe, which necessitated an immediate forced landing. This was subsequently achieved at the disused airfield of Woodbridge. After landing, it was apparent that one of the blades on the right propeller unit had failed at the root. Additionally, it was evident that the departing blade had struck the aircraft nose and one of the left propeller blades.

Description of the aircraft

The Speedtwin ST2 is a low-wing, twin-engine, tandem two-seat prototype aircraft, equipped with two-bladed, variable pitch propellers. The propeller manufacturer supplies propellers for a number of light aircraft types, many of which are administered by the Light Aircraft Association (LAA). The propellers on G-STDL were prototypes, with wooden blades encased in a carbon fibre skin. Threaded aluminium alloy root sections were screwed into steel sleeves within the hub. The sleeves in turn were connected to the pitch-changing mechanism, which is powered by electric actuators mounted on the front face of the hub. Circular clamps attach to the slotted outer portions of the sleeves which, when tightened, prevent rotation of the blades relative to the sleeves.

The propeller assemblies were fitted to the aircraft on 10 June 2008 and had achieved 52 flight hours at the time of the failure.

History of the flight

The aircraft departed Elmsett Airfield for a test flight to be conducted northeast of Felixstowe; the commander was a CAA test pilot. At the time of the incident, the aircraft was maintaining 4,000 ft and accelerating towards its maximum level speed. At approximately 184 mph IAS, engine speed had been selected to 3,000 rpm on both engines. The superchargers were engaged and, some 30 seconds later, a loud bang was heard and the right engine began to vibrate. This was followed by some smoke and a smell of hot oil. The pilot shut down the right engine and selected the propeller switch to the feather position. However, it was soon apparent that the engine was not feathering as the engine continued to rotate. A MAYDAY call was transmitted but any response could not be heard due to the noise in the cockpit. The pilot found he was able to maintain control of the aircraft and also control the descent with power from the left engine. However, he considered that the continuing severe vibration from the right engine made an immediate landing imperative. The disused airfield at Woodbridge was close by where a successful approach and landing were made. Whilst approximately one mile from the airfield, the pilot transmitted a further MAYDAY call to Wattisham to inform them of the aircraft's position. It was subsequently found that vibration had caused the radio to become dislodged from its mounting and it was possible, therefore, that the transmission was not received.

As the aircraft slowed immediately prior to landing, the right engine stopped rotating, and it became clear that one propeller blade was missing. Subsequent inspection revealed that the departing propeller blade had struck the nose of the aircraft as well as the left propeller assembly, partially removing the carbon fibre skin and some of the wood laminations from one of the blades.

Examination of propeller blades

The failed propeller blade was not recovered, although a portion of the root section had remained with the hub. After manufacturing a special tool, this was unscrewed and, together with the other blades, it was subjected to metallurgical examination.

Figure 1 shows the hub in which the root portion of the failed blade, (Figure 2) had been located. Corrosion products were present on the threads in the hub and there was no evidence of a jointing compound having been used in the assembly. The fracture face had propagated around the circumference of the root of a thread and had continued into the adjacent root, causing a 50 mm overlap. A 'thumbnail' feature was visible on the fracture face together with two 'bright' areas; these are shown on the photographs and are designated 'Cracks 1, 2 and 3'. It was concluded that all the cracks were progressive in nature, although outside these areas it was apparent that the fracture was the result of overload. Additional examination of the cracks, using a scanning electron microscope at low power, revealed fracture surface delamination, which is characteristic of stress corrosion cracking (SCC). A section was taken through one of the cracks and it was found that smaller cracks branched off it; all the cracks were intergranular in nature. This, together with the branching feature, is also characteristic of SCC.

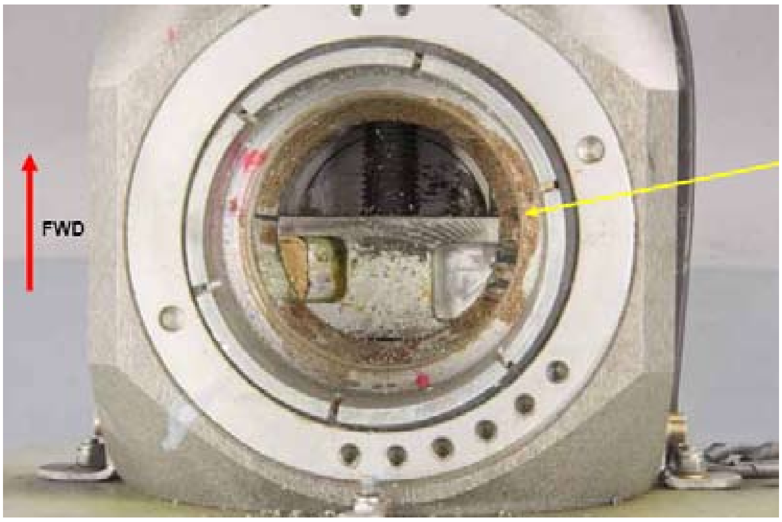

Figure 1

Hub after removal of the failed blade root portion

Figure 2

Failed blade root section showing cracked areas

For SCC to occur, a sustained tensile stress must be present in the material, in a corrosive environment. A microstructural examination indicated that the threads had been machined rather than rolled; this had exposed end grains at the thread roots, which would make them susceptible to SCC[1]. Although a considerable tension would be present in the blade roots during engine operation, the low operating time of 52 hours, compared with their calendar age, led to the conclusion that the most likely source of sustained tensile load was residual stresses arising from the thread machining operation. It is not known whether the blade roots were heat treated following the thread machining operation, but this would have relieved much of the residual stress.

Footnote

[1] Thread rolling is a cold forming process, which imparts a compressive layer to the surface of the material, and which does not result in exposed end grains.

Examination of the damaged left propeller revealed a spiral crack running around the root section of one blade, Figure 3. It was concluded that this was an overload feature that occurred as a result of being struck by the failed right hand blade. The root sections of the remaining left and right blades revealed no sign of cracks, although all displayed evidence of moisture ingress and associated spots of corrosion.

Discussion

Although the propeller assemblies fitted to this aircraft were prototype units and do not necessarily reflect the likely production standards, various features of their design and construction are considered worthy of comment. For example, the assembly consisted of dissimilar metals in contact, ie, the aluminium alloy threaded blade roots were assembled into steel sleeves in the hub, with no jointing compound, or O-ring type seals to protect against moisture ingress. In addition, the blade root threads had been machined, whereas a thread rolling process would have been more appropriate, in that exposed end grains not have resulted. Moreover, rolled threads would have conferred a higher degree of resistance to fatigue cracking.

Conclusions

It was concluded that the right propeller blade failure was the result of stress corrosion cracking within the threads of its root section. This probably occurred due to a combination of residual stresses within the root arising from the thread machining process, and a corrosive environment arising from moisture ingress.

Following this incident, the developers of the Speedtwin aircraft are reviewing the engine/propeller combination, with the probability of alternative suppliers being selected.

Figure 3

View showing crack in root of one blade from the left propeller