Streak Shadow SA-SLA, G-MGPH, 29 July 2001

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Aircraft Type and Registration:	Streak Shadow SA-SLA, G-MGPH	
No & Type of Engines:	1 Rotax 582 piston engine	
Year of Manufacture:	1997	
Date & Time (UTC):	29 July 2001 at 1620 hrs	
Location:	Cockfield, Suffolk	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Propeller, nosewheel and left flap	
Commander's Licence:	Private Pilots Licence (Microlights)	
Commander's Age:	44 years	
Commander's Flying Experience:	1,500 hours (of which 77 were on type)	
	Last 90 days - 36 hours	
	Last 28 days - 12 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and examination of failed parts	

History of the flight

After completing two previous flights that day, the pilot departed Norton with his passenger to fly to North Weald. The first part of the flight was uneventful. Weather conditions were good with a clear sky and a wind of 250°-270° at 5-10 kt. The aircraft was passing Cockfield at 1,000 feet amsl with the engine at its cruise setting of 6,000 RPM and with all indications normal when, without warning, a loud bang was heard and the engine began to overspeed. The pilot shut down the engine and made a forced landing in a wheat field approximately 1/4 mile to the east. During the landing the nosewheel passed over a tractor rut causing it to break off and the aircraft slid several feet on its nose before coming to rest.

The pilot and his passenger were uninjured and exited the aircraft in the normal manner. Neither the pilot nor passenger remembered any unusual vibration prior to the failure. On inspecting the aircraft they observed that the propeller was missing and that the left flap had been damaged. The propeller was found close to houses near the western end of the field but one of the propeller blades was missing and could not be found. Prior to the first flight of that day the pilot stated that he had checked the propeller for security by hand as part of the Daily Inspection. After the accident he checked the engine oil and coolant levels and found them to be normal.

Propeller installation

The three-bladed propeller is manufactured by Precision Propellers and is used in the pusher configuration. Each of the laminated wooden blades is mounted in a two-part plastic pitch block which allows the blade to be set at the desired pitch angle. The blades are then clamped between two aluminium hub plates to form the propeller assembly. This assembly is attached by six M8 DIN 931 bolts, which screw into threaded holes on the gearbox flange, and are torqued to 10 ft.lbf. Locking is provided by stiff nuts installed on the threaded portion of the bolt protruding through the gearbox flange.

The above mentioned method of mounting the propeller is only used on factory-built Shadow aircraft such as G-MGPH. With this method, it is recognised that it is possible to torque tighten the stiff nut to obtain the 10 ft.lbf. torque value without the mounting bolt itself being correctly torqued, such that the propeller is not fully seated on the gearbox flange. To preclude the possibility of incorrect assembly, the aircraft manufacturer recommends a simpler method of mounting the propeller on self-build aircraft. This involves drilling out the threads in the gearbox flange and installing oversize bolts which pass through the gearbox flange. The propeller is then solely clamped to the gearbox flange by the action of torque tightening the stiff nuts.

Engineering investigation

The aircraft was returned to the aircraft manufacturer for examination and repair. The engine and gearbox were found to be in good condition and no evidence of shock loading damage was found. The broken shanks of the six propeller attachment bolts were still located in the threaded holes in the gearbox flange with the locknuts still in place. The propeller and the shanks of five of the six propeller retaining bolts (one had been misplaced) were sent to the AAIB for examination.

The missing propeller blade had fractured along the plane where it emerged from the pitch block at the blade root. It was evident from examination of the fracture face that it had failed in overload and no signs of delamination or any other pre-existing defect were found in the fracture zone. The absence of airframe/engine vibration prior to propeller separation from the aircraft suggested that the missing blade broke off after the propeller departed the engine, probably as a result of striking the left flap.

No evidence of bird remains was seen on the either the propeller or the airframe and DNA tests carried out to look for any subtle evidence of a bird strike proved negative.

Metallurgical examination of the fracture faces of the propeller attachment bolt shanks showed that three had failed in fatigue due to bending originating in the thread root and, whilst the fracture surface of another was badly damaged, its generally flat appearance also suggested a fatigue failure. The fracture face of the final bolt shank inspected showed characteristics of overload failure, this most likely having occurred after the other bolts had failed. The fact that three or possibly four of the bolts had failed due to fatigue in bending suggests that significant repetative side loads were applied by the propeller to the bolts, This would not normally occur if the propeller attachment bolts were correctly torque tightened, since the greater portion of any propeller torsional loads would be reacted by frictional forces between the propeller hub and the gearbox flange and not carried as side loads on the bolts. Evidence of fretting was apparent on the propeller hub plates, particularly on the surface of the plate which abutted against the gearbox flange. The metallurgical examination findings therefore strongly suggest that the propeller mounting bolts were insufficiently tight and, consequently, that there was insufficient clamping force between the propeller hub and the gearbox flange.

Hardness tests on the bolts gave average results of 274 to 280 HV for four of the five bolts and the fifth gave a result of 344 HV. This is equivalent to a tensile strength of between 900 and 1,100 Mpa and falls within the limits of 800 to 1,250 Mpa for the bolts specified in this application by the manufacturer.

Propeller inspection requirements

The CFM Streak Shadow maintenance manual requires the propeller blades to be inspected for damage at the 10-hour, 50-hour and Annual Checks. The back plate and propeller hub must be inspected for condition every 50 hours and at the Annual Check. The propeller on G-MGPH was replaced by the aircraft manufacturer in the Spring of 2001, after the previous propeller was damaged. The aircraft underwent a 50-hour Check in June 2001, which was performed by the aircraft manufacturer. No discrepancies were noted with the propeller installation at that time.

The Rotax Engines Maintenance Plan, 3UL 91E, describes the Daily, Pre-flight and Scheduled Maintenance checks for the engine. These require the propeller to be inspected for damage and security during the Daily Inspection and before every flight. In addition, the Scheduled Maintenance checks call for the propeller balance and tracking to be checked every 25 hours. They also state the propeller mounting bolts should be checked in accordance with the instructions of the propeller manufacturer.

The propeller manufacturer offers guidance on the initial installation and pitch setting of the propeller but does not detail an inspection schedule. However, notes on general propeller care are provided, such as how to deal with abrasion and how to prevent water ingress. Discussions with the propeller manufacturer identified the importance of regular torque checks as the wooden blades are prone to expansion and shrinkage with changes in humidity. It was the opinion of the propeller manufacturer that a torque check of the mounting bolts should be performed after the first 30 minutes of operation, followed by a further check after another one or two hours of operation and then subsequently every 25 hours. The instructions for assembly and care of the propellers have already been amended by the manufacturer to include these new requirements.

Conclusions

The evidence indicated that the propeller separated from the gearbox flange due to a progressive failure in fatigue of a number of the propeller mounting bolts. The remaining bolts failed in overload, causing the sudden loss of the propeller. The most likely source of the problem was incorrect torque tightening of the propeller mounting bolts, or loosening in service, resulting in the propeller not seating correctly on the gearbox flange, thereby allowing bending loads to be applied to the mounting bolts. The method of attachment of the propeller, with the combination of the threaded flange and stiff nuts, provides the opportunity for incorrect assembly. Should the propeller bolts be tightened or checked tightened with the stiffnuts already in place, but without first having backed them off, then the resultant torque readings could mislead the operator. Part or all of the torque applied to the bolt heads could be taken up by friction between the stiffnuts and the gearbox flange and not, as intended, through compression of the propeller hub between the bolt heads and the flange. Such incorrect tightening is unlikely to be evident during the pilot's pre-flight checks for security of attachment of the propeller.

Follow-up Actions

The aircraft manufacturer is proposing a modification to the method of propeller attachment, using hexagon-head bolts which screw directly into the threaded gearbox flange. Positive locking is to be provided by wirelocking between the bolt heads. This should ensure correct installation of the propeller and the wirelocking will provide a visual means of checking the security of attachment of the propeller.