PIK 20E, G-SOAR, 11 July 1999

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Aircraft Type and Registration:	PIK 20E, G-SOAR
No & Type of Engines:	1 Rotax 501 piston engine
Year of Manufacture:	1979
Date & Time (UTC):	11 July 1999 at 1425 hrs
Location:	1 mile west of Chalgrove Airfield, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - None
Injuries:	Crew - None - Passengers - N/A
Nature of Damage:	Separation and loss of complete propeller and hub assembly; propeller strike damage to fuselage structure immediately aft of cockpit
Commander's Licence:	Private Pilot's Licence
Commander's Age:	32 years
Commander's Flying Experience:	697 hours (of which 114 were on type) Last 90 days - 46 hours Last 28 days - 25 hours
Information Source:	AAIB Field Investigation

History of the flight

The motor glider was on a cross country soaring flight from Bideford-on-Avon, routing via Stokenchurch before returning to Bideford. Having turned at Stokenchurch, it appeared to the pilot that an engine start would be required and he flew towards Chalgrove Airfield before deploying the engine and starting it successfully. The aircraft was at 1,000 feet agl on a long baseleg for Runway 36 at Chalgrove at this time. After starting the engine, the pilot changed course for Bideford. A little over one minute later, there was a loud bang followed immediately by the engine over-speeding. The engine was shut down using the ignition master switch and upon looking back over his shoulder the pilot could see that the propeller was missing. However, he was able to retract the engine without problem and then made a successful forced landing about one mile west of Chalgrove Airfield.

It was found that the propeller had separated completely, together with the hub and drive belt, and propeller strike damage was evident on the top of the fuselage behind the cockpit.

PIK 20E engine installation

The PIK 20E motor glider has an inverted Rotax 501 piston engine mounted near the top of a retractable pylon, which hinges forward and upward from a stowage compartment in the fuselage immediately aft of the wing centre-section. The engine drives a two-bladed fixed-pitch propeller through an exposed toothed-belt reduction drive mechanism. The reduction drive is peculiar to the PIK series of motor gliders, and differs considerably from the type of reduction drive typically found on Rotax engine installations. On the Pick installation, the propeller is bolted directly to the forward face of the driven pulley, which rotates about a fixed stub shaft at the top of the pylon, supported by taper bearings.

The propeller hub/pulley assembly is retained on the stub shaft by a single retention nut, which serves both to provide a means of adjusting the pre-load on the bearing and to react the thrust loads from the propeller, which otherwise would tend to cause the whole assembly to migrate forward off the shaft. The nut has a left hand thread, and consequently the right hand rotation of the tractor propeller (viewed from the rear) will tend to tighten the retaining nut. A tabbed lock plate prevents the nut from backing off, or from tightening beyond its set position. Once the propeller has been bolted to the forward face of the hub pulley, access to the nut and lock plate is blocked both physically and visually.

Examination of the aircraft

It was evident that as the hub/pulley assembly had slid forward off the shaft, the (still present) toothed belt had caused the propeller disc to pitch downwards allowing the rotating blades to strike the fibreglass shell of the fuselage in two places just behind the canopy. This had resulted in some longitudinal splitting of the structure, and partial penetration in two places. Minor secondary damage was noted on the exhaust muffler, immediately behind the propeller hub. Deformation and associated witness marks were apparent on the belt locating flanges of the drive pulley on the engine crankshaft; all such damage had been produced during the separation of the propeller.

The positions and orientation of the main propeller strikes on the fuselage, together with some adjacent fainter witness marks, were consistent with the propeller disc having been close to a horizontal attitude at the time of the strikes, at which instant the opposing blades of the propeller must have passed just above the canopy glazing, in close proximity to the pilot's head. Whilst the structural integrity of the fuselage was not seriously compromised by these strikes, there was thus a significant risk of serious or fatal injury to the pilot if the propeller blades had actually struck the canopy.

Detailed examination of the propeller attachment

The thread on the stub shaft was in good condition and it was apparent that the nut had loosened and separated from the shaft allowing the complete propeller hub assembly, comprising the driven pulley, its bearings, the nut, its locking plate and the attached propeller, to separate together with the toothed belt.

Detailed examination of the propeller stub shaft revealed some old bruising on the land for the rear bearing, which had evidently been present for some considerable time prior to the incident. This was overlaid by more recent damage, the latter being consistent with a migration of the rear bearing assembly forward along the shaft during the separation sequence. Heavy damage was also noted on the land supporting the forward bearing, comprising a series of helical score marks consistent with

the front bearing migrating forward along the shaft. The orientation of these helical marks were consistent with the direction of propeller rotation, and had evidently been produced as the bearing inner race screwed itself off the shaft during the separation process. Viewed under high magnification, a series of finely spaced striated indentations were visible running along the main scores, consistent with a high frequency rocking oscillation of the propeller disc as it migrated forward. The retaining thread itself was in good condition, as was the groove for the lock tag. It was therefore apparent that the nut itself had backed off the thread, and had not been forced off.

The separated parts of the propeller assembly were not recovered, the sole surviving component being a thin washer which had remained in place at the extreme rear of the stub shaft. This had evidently served as a spacer between the back face of the rear bearing inner face and the locating shoulder on the shaft. The sectional profile of this washer was not flat, but was 'dished' in a manner which matched the radiused corner profile of the shoulder on the shaft. Visually, it appeared that the profile adopted by the washer had resulted from it being crushed back against the shoulder radius during assembly. Extensive efforts to establish the normal profile of this washer, and to determine the precise make-up of the propeller assembly, were unsuccessful due to a lack of clarity in the only available drawings.

Because the principal components were never recovered, it was not possible to determine with certainty the underlying reason for the separation of the propeller assembly. However, it was evident that the nut would have tended to tighten rather than to loosen under the influence of propeller rotation, and it follows therefore that the nut must have come loose and separated from the shaft before the propeller assembly had started to migrate forward. (The bearings should be an interference fit on the stub shaft, requiring differential heating/cooling during removal/installation: consequently, it would be quite possible for the nut to have come off the shaft without the propeller moving forward, and for it to have operated for some time in that condition before eventually starting to migrate forward under the influence of propeller thrust). The precise reason why the nut came loose in the first instance, however, remained unresolved.

Previous history of propeller separations on PIK motor gliders

Previous instances of propeller hub separation have occurred on PIK 20E motor gliders and have been attributed to failure of the locking tab arrangement on the retention nut.

A Draft Airworthiness Directive 1 63-303.61/90-239, issued by the West German airworthiness authority (LBA) in 1990, addressed the issue of propeller hub security. This specified, in summary, dismantling of the propeller hub followed by careful inspection of the faces of the retention nut and installation of thick shims if necessary, and re-assembly using a new lock plate. This procedure was to be repeated at intervals of 10 engine operating hours until further notice, pending attempts to find a Type Specialist in West Germany with whom improvements to the design of the unit could be developed.

Within the UK, Draft Airworthiness Directive 1 63-303.61/90-239 was adopted by the British Gliding Association (BGA). In light of the propeller separation involving G-SOAR, the BGA has re-issued BGA Technical Newsheet 7-8/99.

The log book for G-SOAR indicated that the lock plate was replaced, as required in the Directive, during the course of a Certificate of Airworthiness inspection carried out on 26 May 1999, some 15 flying hours prior to this accident.