Replica Campbell Cricket Gyrocopter, G-BVOH

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Aircraft Type and Registration:	Replica Campbell Cricket Gyrocopter, G-BVOH
No & Type of Engines:	1 Rotax 532 piston engine
Year of Manufacture:	1995
Date & Time (UTC):	14 August 1997 at 1845 hrs
Location:	South side of Carlisle Airport, Cumbria
Type of Flight:	Private (Training)
Persons on Board:	Crew - 1 - Passengers - None
Injuries:	Crew - Serious (back) - Passengers - N/A
Nature of Damage:	Rotor blades bent, propeller destroyed, engine shock loaded, mast axle and seat broken, keel bent
Commander's Licence:	Student Pilot
Commander's Age:	36 years
Commander's Flying Experience:	45 hours (of which 38 hours were on type) Last 90 days - 30 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and liaison with AAIB concerning additional work

History of the flight

The single seat gyrocopter was being used by its student pilot/owner for instructed flying. The instructor was standing on the airfield, observing the aircraft and instructing the student by radio.

The student took off normally and, after climbing to about 500 feet agl, manoeuvred until he had established where his instructor was standing. The instructor asked the student to circle to the right and, when he was satisfied with the performance of this manoeuvre, asked him to circle to the left. Shortly after starting the turn to the left, the student suddenly felt a mild vibration and thought that he might have allowed the airspeed to decay. On checking his air speed indicator he observed, however, that although the airspeed was low it was acceptable. To increase the airspeed and roll out of the turn, the student attempted to move the control stick forward and to the right. At this moment, however, the gyrocopter began to circle to the left and to lose height, whilst at the same time the controls became totally ineffective. The aircraft descended in what was described by the instructor as a "flat left rotation" until it struck the ground and fell onto its left side. However the student pilot was able to undo his harness and climb out of the wreckage. His instructor and the Airfield Fire Service arrived about three minutes after the impact and the pilot was then taken to hospital.

Examination of the wreckage and controls

Subsequent initial examination of the aircraft by the pilot/owner found that the bulk of the damage sustained was consistent with the predominantly vertical impact, with the rotor contacting the ground whilst still turning. Examination of the controls showed that the only disconnection was at the spherical bearing rod-end which acted as the control stick pivot bearing. This had failed in bending in a direction which was consistent with its being loaded in a vertical sense, with the rod-end being pulled upwards relative to the stick. Examination of the control stops at the rotor head showed that although there was evidence of the aft pitch (back flapping) stop having made contact during service there was no evidence of contact on the forward stop ever having occurred. It was also noted that both of the lateral stops had evidence of contact.

Fracture mechanism of the rod-end

Inspection of the fractured rod-end showed that the threaded portion of the rod-end had failed at a point level with the outer face of the lock nut which locked the rod-end on the aft end of the control stick. The failure appeared to have occurred in a series of 'steps' and subsequent metallurgical examination showed that the failure had been cyclic, but over a very low number of high stress bending loads. The cracking had initiated at the top of the thread (in aircraft orientation), indicating that the failure had resulted from tensile loads in the control rods from the stick to the rotor torsion beam.

Pre-flight inspection observations

The pilot/owner, who had no previous experience of gyroplanes, had recently purchased the aircraft from its original builder. At that time it had a valid Permit to Fly and had not, so far as he was aware, been modified or involved in any damaging incidents since it had been built. On the afternoon of the accident, whilst waiting for his instructor, he had conducted a particularly thorough pre-flight inspection in the course of which he had noticed that there was a gap of about 2 mm which remained between the torque beam and the rotor head front stop when the stick was at its forward limit of travel. He observed that this was not the case with the aft and both lateral head stops which were contacted before the stick had reached its stops. He examined the stick pitch stops, which consisted of bolts across the slot in which the stick moved and observed that, whilst the upper stop bolt had only a thin plastic sleeve over it, the lower bolt had a thick sleeve made from what appeared to be fuel hose. From a subsequent conversation with the builder, three days after the accident, the owner understood that the purpose of this sleeve was to prevent abrasion of the stick paint finish.

Subsequent rebuild and tests

The pilot/owner rebuilt the aircraft and subsequently conducted, with assistance and advice from the AAIB, a series of instrumented trials to attempt to quantify and identify the source of the loads which had caused the rod-end failure. During the rebuild, it was observed that there had been variations from the original design specification in the range of pitch control movement and also relating to the angle at which the aircraft hung from its gimbal head. These variations were eliminated during the rebuild.

The trials were performed with strain gauges fitted on the two vertical control rods: these gauges were calibrated and the summed outputs recorded on a datalogger. Because of the sampling rate of the system, the peak loads recorded were not necessarily the actual peak loads experienced by the rods.

The basic trial was directed towards establishing the loads generated at the control stick pivot bearing as a result of taxiing the aircraft across rough ground with the stick held on the forward stop. Trials were performed both with the rotor turning and with the rotor static and tied forwards. Each of these tests was conducted with two different stop settings: one with the head stops set correctly, contacting before the stick touched its forward stop; and another with the stop adjusted so that there was a 2 mm gap at the head stop when the control stick was on its forward stop.

The results of these trials showed that, with the head stop correctly set, no significant loads (approx. 0.2 kiloNewtons (kN) were induced in the vertical rods. With the stop set to give a 2 mm gap at the head, however, combined tensile loads in the rods of up to 0.5 kN were recorded with the rotor turning and up to 1.7 kN with the rotor tied. A separate static test on a similar rod-end showed that the equivalent rod load to induce failure in bending was 4.2 kN.

Conclusions

These trials therefore indicated that the loading of both the control rods and the pivot rod-end was substantially increased by the incorrect setting of the relative positions of the head and stick stops. Although loads sufficient to break the rod-end were not demonstrated during the trials, the uncertainty that the actual peak loads were recorded allows the possibility that such loads might be developed in adverse circumstances. The modification of the lower stick stop from the design standard was apparently either not observed, or not considered significant, by the inspectors who had passed the machine as suitable to hold a Permit to Fly.