INCIDENT

Aircraft Type and Registration:	Agusta A109S Grand, G-CGRI
No & Type of Engines:	2 Pratt & Whitney Canada PW207C turboshaft engines
Year of Manufacture:	2005
Date & Time (UTC):	7 April 2006 at 0919 hrs
Location:	Liskeard, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Tail rotor trunnion assembly, tail rotor blade and vertical fin damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	10,880 hours (of which 1,100 were on type) Last 90 days - 37 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent telephone enquires

Synopsis

During the cruise, some four minutes into the flight, the helicopter suffered severe vibration. The pilot carried out an autorotation and landed safely. Subsequent investigation revealed that one of the two tail-rotor trunnion flange caps had separated, causing damage to a tail-rotor blade and the vertical fin.

The metallurgical examination showed the failure to be due to an initial clockwise torsional overload followed by a final axial tensile overload. It is possible that the initial clockwise torsional overload was applied either during the manufacture of the helicopter or during maintenance activity during the night prior to the incident flight. The maintenance manual did not contain the specific torque loading for the trunnion flange caps.

The helicopter manufacturer has since issued torque loading figures for the flange caps and has amended the maintenance manual accordingly.

History of the flight

Whilst in the cruise, and about four minutes into the flight, the pilot suddenly experienced a high level of vibration. At the time, the helicopter was flying at 155 kt and at 1,500 feet. The pilot entered into an autorotation and declared a MAYDAY, before landing safely in a

field. He shut down the helicopter, noticing that the vibration seemed to worsen during this procedure. He was uninjured and exited the helicopter normally.

Inspection of the helicopter revealed that one of the tail-rotor trunnion flange caps had separated, causing damage to a tail-rotor blade and the vertical fin.

Tail-rotor system description

The tail rotor assembly consists of two rotor blades, driven from a gearbox via a drive shaft and a trunnion. The drive shaft runs from the gearbox, located within the tail boom, and connects onto splines within the tail-rotor trunnion. The trunnion then transfers drive, through the surrounding hub, to the rotor blades.

The A109S 'Grand' (Figure 1) has flange caps, with an internal thread, which locate onto the stubs at each end of the trunnion. Lock nuts then secure the assembly in place within the hub.

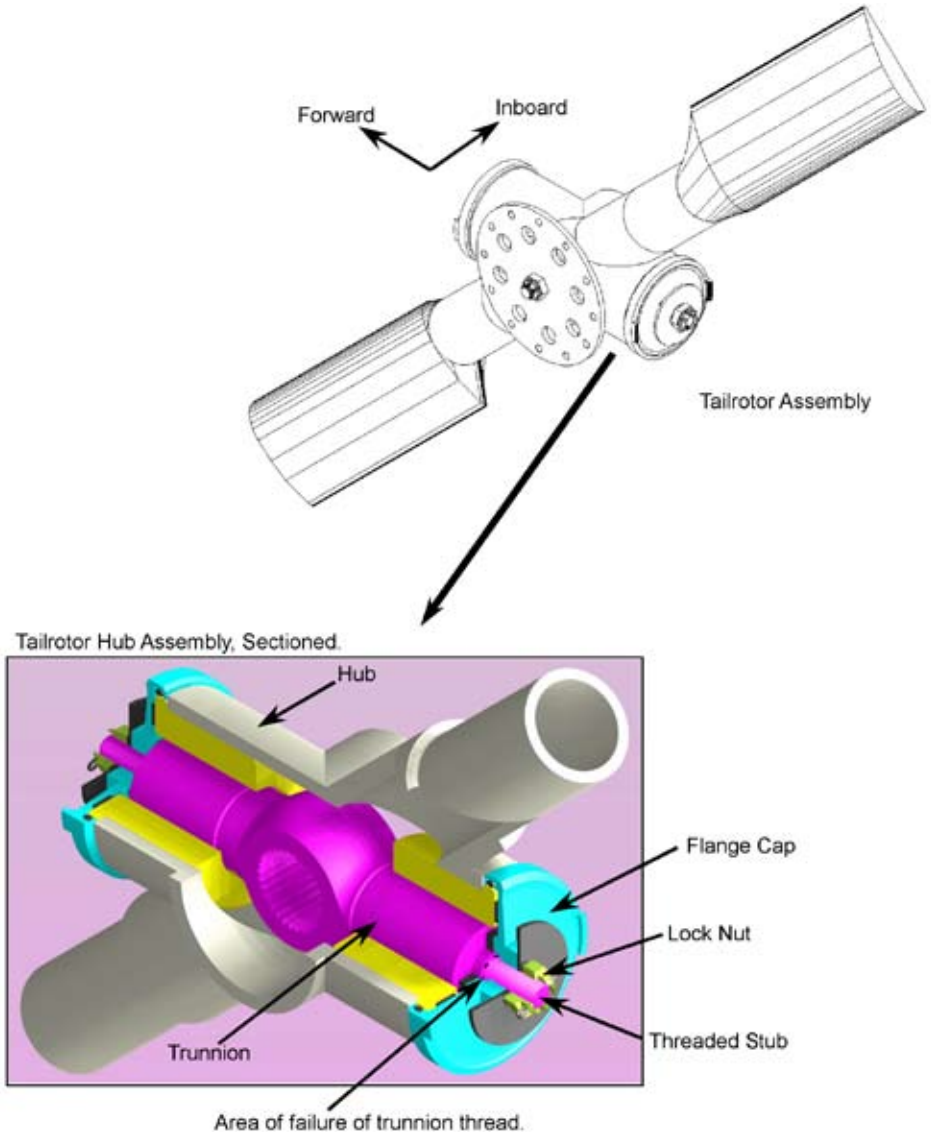

Figure 1

Trunnion assembly and drive

Component examination

The maintenance organisation removed the failed tail-rotor trunnion for detailed examination by the helicopter manufacturer. The manufacturer's metallurgical report revealed that the trunnion had failed in the undercut of one of the threaded stubs and stated that the fracture had initiated due to clockwise torsion, followed by a final tensile axial overload; there was no sign of a fatigue failure mechanism.

The metallurgist had then compared the failure on G-CGRI to four other trunnion thread failures. One of these had failed, during maintenance, on an Agusta A119 'Koala', due to an over torque as a result of a damaged thread. Two of the failures were threads broken, on purpose, by the metallurgist during proof tests. The last failure example was provided by applying a torsional load on the opposite stub thread of the trunnion removed from G-CGRI. The failure was achieved by seizing the flange cap onto the thread and then applying an increasing torque.

Comparison of these four failures, and the incident failure on G-CGRI, revealed that they were similar. However, there was a difference in that it was only the failure on G-CGRI that had shown a final axial tensile failure, whereas the others had a final torsional failure.

Maintenance history

Prior to the incident flight the helicopter had undergone maintenance. One of the tasks required the removal of the tail-rotor trunnion assembly; this necessitated the removal of the flange cap retaining nuts and the flange caps.

During the removal of the flange caps, it became apparent that one of the two flange caps could not be fully unscrewed, by hand, from one of the stubs. So, the flange cap was unscrewed until just prior to the point at which it bound on the thread, enabling the removal of the trunnion by full removal of the remaining cap.

Following the maintenance task, the engineer reinstalled the trunnion assembly, using the components originally removed from G-CGRI. The aircraft maintenance manual did not contain specific information on the installation of the threaded flange caps, so the engineer used the helicopter manufacturer's standard practices for torque loading of threaded components. Based on the size of the stub thread the engineer applied a torque of 70 lbf in. Subsequent tests of the tail rotor system were all within the maintenance manual limits.

This was the first time the tail-rotor trunnion assembly had been disturbed since the helicopter had entered service from manufacture.

Maintenance instructions

The helicopter manufacturer produced the Agusta A109S 'Grand' maintenance manual using a previous manual already in existence for the Agusta A109E 'Power'. However, the two helicopters have significantly different tail-rotor drive designs, with the A109S 'Grand' system similar to that on the A119 'Koala'. The A109E 'Power' does not use threaded trunnion flange caps that engage onto the trunnion threads. Instead, the unthreaded trunnion flange caps are located onto the hub and fixed by lock nuts alone.

This difference between the two designs led to the omission of torque loading figures for the installation of the threaded trunnion flange caps on the A109S. The manufacturer had, however, correctly quoted torque-loading figures for the lock nut.

Discussion

The vibration felt by the pilot during the very short flight was as a direct result of the loss of one of the tail-rotor trunnion flange caps. His prompt action, to land immediately, was prudent and prevented a worse outcome.

The metallurgical examination of the failed tail-rotor trunnion stub, revealed an initial clockwise torsional failure with a final tensile overload. Comparison with stubs that were, later, deliberately failed in torsion (including the remaining stub of G-CGRI's trunnion) showed similarities in the failures.

The failure on G-CGRI occurred just five minutes into the first flight after the helicopter had been in maintenance. During this maintenance input the tail-rotor trunnion assembly had to be removed, necessitating the removal of the flange caps. One flange cap could not be fully unscrewed by hand; the engineer later stated that he never applied a high torque at this stage. Indeed, the initial torsional failure was in a clockwise direction; had an over torque been applied whilst undoing the flange cap, the torsion would have been anti-clockwise.

During the reassembly of the tail-rotor trunnion assembly, the engineer was aware that the aircraft maintenance manual (AMM) did not contain the full instructions for the installation of the threaded flange caps. Therefore, he applied his own engineering knowledge and referred to the manufacturer's standard practices to obtain a torque figure. The calculated torque of 70 lbf in, which was then applied, was based on the size of the stub. This was well within the manufacturer's quoted limit of torque loading of 69-95 lbf in, which appeared in literature produced after the incident.

This had been the first disturbance of the tail-rotor trunnion assembly and its flange caps since the helicopter entered service. The only previous occasion in which a torque load would have been applied to the threaded stub, in a clockwise direction, would have been during the original installation of the trunnion during manufacturer.

The failure mode of the stub indicated that, at some point prior to the incident, a clockwise over torque had been applied, causing a crack to develop but not a complete failure of the stub. This could have occurred either during the original installation of the trunnion at manufacture or during the maintenance input immediately prior to the incident. The crack had developed within the root of one of the threads, which may have been difficult to see during a visual examination. Therefore, if a crack had developed following the installation of the trunnion at manufacture, it is unlikely this would have been identified during the subsequent disassembly at the maintenance facility. It is also possible that, had a pre-existing crack been present, then the torque applied by the engineer during the reassembly at the maintenance facility, although within later published limits, may have lengthened the crack to a length at which the normal operating axial tensile load would allow the crack to grow rapidly, causing the final tensile fracture.

In summary, a factor in the initial over torque of the stub, was the lack of published torque figures for the installation of the flange caps.

Safety action

The helicopter manufacturer has amended the maintenance manual for the A109S to introduce torque loading figures for the trunnion flange caps. It also issued an Alert Bulletin to instruct operators to inspect the tail-rotor trunnion for any damage and correct installation of the flange caps.