AIRCRAFT ACCIDENT REPORT No 7/2010

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REPORT ON THE ACCIDENT TO AEROSPATIALE (EUROCOPTER) AS 332L SUPER PUMA, G-PUMI AT ABERDEEN AIRPORT, SCOTLAND ON 13 OCTOBER 2006

Registered Owner and Operator:	Bristow Helicopters Limited
Aircraft Type and model:	Aerospatiale (Eurocopter) AS 332L Super Puma
Nationality:	United Kingdom
Registration:	G-PUMI
Place of Incident:	Aberdeen Airport, Scotland
Date and Time:	13 October 2006 at 1220 hrs

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) by the Operator's Flight Safety Officer. The following Inspectors participated in the investigation:

Mr R D G Carter	Investigator-in-charge
Mr C A Protheroe	Engineering
Miss G M Dean	Operations
Mr P Wivell	Flight Recorders

The aircraft was departing from Runway 14 for a flight to oil platforms in the North Sea, carrying 13 passengers. Five seconds into the takeoff the crew heard a bang and an abnormal vibration started. The crew rejected the takeoff and landed back on the runway. The aircraft started to taxi but the severe vibration continued so the commander stopped and shut down the helicopter on the threshold of Runway 32.

Initial examination showed that one main rotor blade spindle had fractured, through the lower section of its attachment yoke on the leading side of the spindle. Post-fracture plastic deformation of the lug had stretched open the fracture, separating the faces by some 12 mm.

As a result of this accident the helicopter manufacturer published an Emergency Alert Service Bulletin, requiring periodic inspections, and this was subsequently mandated by the European Aviation Safety Agency (EASA) as an Airworthiness Directive. In July 2009 the manufacturer issued Service Bulletins which introduced a 'wet' assembly procedure, with new nuts, for the main rotor blade spindles. This eliminated the requirement for the repetitive inspection procedure and was made mandatory by the issue of an Airworthiness Directive (AD) by the EASA.

The investigation identified the following causal factors for the failure of the spindle yoke:

(i) Wear on the flapping hinge inner race.

(ii) Excessive clamping pre-load across the yoke, due to the tie bolt being torqued to the specified dry value in the presence of grease when it was reinstalled some 175 hours prior to failure of the yoke.

(iii) Significant hoop stresses in the bore of the yoke due to adverse tolerance stacking and the associated interference fit of the bush in the yoke.

The following were considered as contributory factors in the failure:

(i) Flight loads biased towards the high-speed level flight condition, slightly higher than those generated by normal level flight cruise conditions.

(ii) A minor deviation in corner radius profile at the inner end of the bore of the yoke, with a small increase in the attendant stress concentration.

(iii) A minor reduction, at the fatigue origin site, in the intensity of the compressive surface layer stresses from the shot-peen process.

(iv) Flight loads in the spindle yoke slightly higher than anticipated in certification fatigue testing, due to the action of the lead-lag dampers (frequency adaptors).

One Safety Recommendation is made, to the EASA, concerning HUMS detection in helicopter rotating systems.

Findings

The accident flight

1) The flight crew were properly licensed and qualified to conduct the flight.

2) The flight crew were suitably rested and held valid medical certificates.

3) Five seconds after lifting off to begin a flight to the Britannia Platform, the lower half of the lug forming the leading side of the Blue main blade spindle yoke fractured.

4) The failure was accompanied by a bang and very heavy vibration, and the crew immediately landed back on Runway 14. The aircraft was shut down and the passengers disembarked whilst still on the runway.

The fracture mechanism

5) The yoke had failed in fatigue, due to a crack that originated at the corner radius on the inner end of the bore in the lug that accommodates the flapping hinge pin. The fatigue crack propagated through some 90% of the cross-section before the remaining material became overloaded and ruptured.

6) Analysis of the fracture faces indicated that the primary fatigue crack had propagated over a period of some 90 rotor starts, with the crack breaking through the visibly accessible lower surface of the lug 15 to 17 rotor starts prior to the final rupture.

7) The aircraft's flight logs indicated corresponding flight times of 258 hrs for propagation to failure, of which 47-54 flight

hours occurred after the crack had broken through the visible lower surface of the yoke.

8) Sacrificial washers bonded to the inner faces of the lugs were also cracked along fracture lines parallel with the plane of the yoke fracture.

9) Flight loads measured in flight trials were broadly comparable to those upon which the original design and certification, including fatigue testing of the spindle, was based. The minor differences were inconsequential in any potential primary causal mechanism.

10) None of the fatigue testing had identified any potential failure of the yoke section of the spindle and failures had involved the main body of the spindle.

11) Failures of the spindle lugs had occurred in service at positions comparable to the G-PUMI failure, only on earlier designs of spindle with thinner (15 mm) yokes.

12) Initiation of earlier fractures had been attributed to fretting between the inner face of the yoke and the flapping hinge inner race with no sacrificial washer, to be introduced later specifically to prevent fretting failures of this type.

13) No significant deviations from specification or drawings were found in the failed blade spindle forging, or any of the associated components.

14) Evidence of wear was found on the end faces of the flapping hinge bearing inner race, the extent of which was close to the maximum measured across a small sample of spindles undergoing overhaul by the aircraft manufacturer.

15) Traces of grease were found on the tie bolt passing through the centre of the flapping hinge pin and laboratory testing showed that application of the specified dry torque to a lubricated tie bolt induced a pre-load substantially higher than the manufacturer intended.

16) Excessive tie bolt tension, due to grease, combined with wear gaps between the yoke inner faces and the ends of the hinge bearing inner race, will cause the yoke arms to deform inwards and adopt a reflex mode of flexure which induces significant standing (static) stresses in the yoke at the fatigue origin site.

17) It is likely that only trace amounts of grease had contaminated the tie bolt, introduced unwittingly as the tie bolt came into contact with extraneous grease in the bore of the flapping hinge pin, as the bolt was reinstalled. In such circumstances, there would have been no indication to the person installing the bolt that contamination had occurred.

18) The superposition of alternating stresses, caused by in-flight loading, onto these large standing stresses was shown to create conditions capable of fatigue crack initiation at the fracture site.

Safety Recommendation

Safety Recommendation 2010-027

It is recommended that the European Aviation Safety Agency, with the assistance of the Civil Aviation Authority, conduct a review of options for extending the scope of HUMS detection into the rotating systems of helicopters.