Havarikommisjonen for Sivil Luftfart HSL

REPORT

P.O. Box 213, N-2001 Lillestrøm, Norway
Telephone: +47 64 84 57 60
Fax: +47 64 84 57 70

RAP: 28/2000
Submitted: 14.06.2000

Aircraft	
-type and reg.:	Eurocopter AS 332L Super Puma, LN-OND
-year of manufacture:	1985
-engine:	Two Turbomeca Makila 1A engines
Radio call signal:	NOR 010
Date and time:	20 October 1998, at 12.25 hours
Location of incident:	In the North Sea at A47 (approx. 47 nautical miles from land along Alpha track on the way to the 'Tor' oil rig XEKH)
Type of incident:	Serious aircraft incident, engine failure with autorotation and loss of height
Type of flight:	Commercial, not scheduled
Weather conditions:	Wind: 340^o 10 kt. Scattered clouds. Temperature/Dew point: 6 ^{o}C/5 ^{o}C. QNH: 1007 hPa Observations made at the 'Ekofisk Field' indicate that the sea temperature was 10.2 ^{o}C, wind speed was 5.7 m/s and the wave height 2.5 m (maximum 4.2 m)
Light conditions:	Daylight
Flying conditions:	VMC
Flight plan:	IFR
Persons on board:	Crew of 2 and 16 passengers
Injuries:	None
Damage to aircraft:	Damage to left engine
Pilot-in-Command	
-sex, age :	Male, 33 years old
-certificate:	ATPL-H
- flying experience:	3 570 flight hours with helicopters, 2 230 flight hours of which were on type. 60 flight hours during the previous 30 days and 4 hours 35 minutes during the last 3 days
Information sources:	Pilot-in-Command's report and supplementary information from the company. Reports from Turbomeca, GKN Westland, DNMI, Esso Norge AS and own investigations.

All reported times in this bulletin are in local time (UTC +2 hours) unless otherwise indicated.

FACTUAL INFORMATION: HISTORY OF THE FLIGHT

LN-OND from *Norsk Helikopter AS*, was 'en route' on an IFR flightplan from Stavanger Airport Sola (ENZV) to the oil rig 'Tor' (XEKH). The helicopter, with call sign NOR 010, took of at 12.05 hours. The flight proceeded normally at an altitude of 2 000 ft until the crew at 12:23:04 hours discovered that the torque on the right engine (Tq 2) started to rise and became unstable. The RPM of the gas turbines (Ng 1 and Ng 2) increased correspondingly. No other indications were observed at that time. The crew then noticed an unusual engine noise. The torque indicator was set to indicate separate values for Tq 1 and Tq 2 (crosshatched position). This showed that the torque value on the left engine was correspondingly low. The crew analysed the situation and got the impression that the problem was related to the right engine. An unusual sound and an increasing RPM could be heard, and in order to prevent overspeed the Pilot-in-Command took the right 'Fuel Flow Control Lever' (FFCL) out of 'Flight detent' and back into 'Manual governing range'. Ng 2 then dropped towards 'Flight idle' speed (approximately 75 – 80%). At the same time, the Co-pilot, who was the 'flying pilot', reduced the collective pitch to 14^{o} (safety pitch) so as to maintain the rotor RPM (Nr). The noise from the engine area then increased substantially, and the warning indicator for high Nr came on for a short period. Later analysis of the helicopter's Flight Data Recorder (FDR) showed that the rotor RPM reached 109% for one second before it was stabilised by the Co-pilot. The Ng 1 reached in this period 101.3% and this may explain the high Nr. The collective pitch was then reduced to 7^{o} and the helicopter entered autorotation at a speed of 80 kt.

At 12:25:30 hours, the Pilot-in-Command sent a distress signal, 3 times MAYDAY. At that time , the crew was confronted with a large number of alarms and warnings in the form of lights and sound signals. At the same time, the intense noise from the engine area began to diminish. The crew then observed that Ng 1 had dropped to below 20%, but an attempt to start this engine only resulted in excessive turbine temperature. The Co-pilot informed the passengers that they should prepare for an emergency landing at sea, and asked them to assume the 'brace position'. Stavanger Air Traffic Control (ATCC) was informed that they were about to perform an emergency landing at sea, and that they were positioned on 'Alpha track' 13 nautical miles from A60. At this time, Stavanger ATCC observed on radar that the descending helicopter passed an altitude of 600 ft on its way down.

At 12:26:46 hours, the crew ascertained that the right engine apparently was operating normally with Ng 2 of approx. 80%, and the right FFCL was pushed in to the 'Flight detent' position. The engine reacted normally and the descent was halted at an altitude of 500 ft. The crew then set course towards land. At that time, the left engine was shut down and the cockpit was 'cleaned up'. The helicopter gradually climbed to an altitude of 1 000 ft. Stavanger ATCC was notified of the situation and the passengers were briefed.

At 12:31:30 hours, it was established that the right engine was functioning normally and the distress signal was downgraded to a PAN message. Another of the company's helicopters (NOR 080) was in a period directed towards LN-OND for a period of time, and one of the military Sea King search & rescue helicopters took off from Sola to intercept LN-OND.

LN-OND was escorted by the Sea King for the last part of the flight and made a rolling landing on runway 36 at Sola without further problems at 13.03 hours.

The helicopter's cockpit voice recorder (CVR) and FDR were removed after the landing and sent to the UK Air Accident Investigation Branch (AAIB) for analysis. The helicopter was further examined by the company, and it was ascertained that the housing of the axial compressor on the left engine (serial no. 477) was split open all the way along its circumference, with a gap 10 – 20 mm wide. The engine was partly dismantled with the assistance of the engine manufacturer Turbomeca. It was discovered that the engine's bearing number 2 (a roller bearing behind the axial compressor) had failed and it was decided to send the engine to the manufacturer for closer investigation. The French Air Accident Investigation Branch (BEA) was represented during this work. The following points are taken from 'Turbomeca Report No. 9323' and 'Turbomeca Investigation Report No. 1066':

- no fault was found with the engine's oil system
- the problem started in bearing no. 2 for unknown reason
- signs of fatigue damage and fatigue fracture were found in the 'bearing cage', which in turn led to the total failure of the bearing
- the failure of the bearing permitted movement of the compressor rotor, with consequent contact between stator and rotor
- this contact led to the loosening of the stator stage no. 2 which then rotated inside the compressor housing, caused friction, overheating and eventually the melting and splitting of the housing
- it was found that this in turn had caused damage to bearings nos. 3 and 4, the centrifugal compressor and the turbine wheel of the gas turbine
- a large amount of metallic particles was found on the magnetic plugs in the oil system for modules 2, 4 and the oil supply. Only few particles was found on the magnetic plugs for modules 1 and 5
- the bearing in question was of the type SNFA SNB 40/10, part no. 9.606.05080.6 with the serial no. 96.219
- there was no warning light connected to the magnetic plugs in the engine's oil system
- Turbomeca is studying the possibility of replacing this type of bearing with a stronger type.

At the time of the incident, the engine (modules 2 and 3) had a total running time of 8 611 flying hours and 4 355 cycles. It had flown for 2 327 hours since its last overhaul, and 1 187 hours since the last repair work. The bearing in question, along with the other high-speed bearings in the engine, had been replaced during the last overhaul. Other maintenance carried out on the engine before the incident where:

- 'Max. Ng check', 259 flying hours before
- engine wash, 163 flying hours before
- 'Rundown check', 36 flying hours before
- inspection of all magnetic plugs in the engine's oil system, 30 minutes before

The helicopter's Health and Usage Monitoring System (HUMS) was analysed by the company after the incident. The available information did not reveal development of any fault prior to the incident. The raw data from the HUMS was sent to GKN Westland Helicopters for further analysis in case more information could be extracted from the existing records. Analyses were made of information gathered from the left engine 'Engine forward location'. An analysis of the frequency range 0 – 30 kHz showed that the frequency produced by the compressor blades (approx. 7 500 Hz) changed significantly at 12.19 hours during the flight that suffered the engine failure. It has not been possible to establish the cause of this change. A corresponding analysis of the frequency range 0 – 2 kHz showed that harmonics had appeared in addition to the basic frequency, equivalent to 3 times Ng RPM (approx. 1 500 Hz), on a flight on 12 October (18 hours and 49 minutes flying time before the incident) and that these continued until the time of the engine failure. According to the record made on 20 October at 12.19 hours, the entire frequency picture had changed and several peaks had occurred which ranged from 315 Hz to 1 600 Hz. It was not possible to explain the precise reason for this, but it was indicated that the vibrations could have been caused by contact between the rotor and stator in the compressor. The Westland report concludes that the main failure occurred during the final flight. The only otter observation was the changes in frequency around 3 times Ng.

The helicopter in question had five magnetic plugs in the oil systems for each engine. There were no warning lights connected to these, so they had to be removed for inspection. Eurocopter has developed a modification that consists of an extra magnetic plug wired to a warning light and installed in the oil return line. After this incident, the company decided to fit pluggs of this type in all its helicopters.

There exists no checklist that fully cowers the situation that developed. The most relevant assessable checklist was the company checklist for 'Engine Governor Malfunction':

'Engine Governor Malfunction

CONSEQUENCES:

ALARM + DIFF NG Possible: POWER 1 or POWER 2 + Ng fluctuations (ref. Note 2)

Governor failure may cause: Ng to 2 ½ minute power
Ng to idle
Ng frozen at 28 200 RPM

IMMEDIATE ACTIONS:

1. COLLECTIVE/FFCL……………………………….ADJUST TO MAINTAIN NR

SUBSEQUENT ACTIONS:

2. TQ INDICATOR…………………………..……………………..X-HATCHED
3. AFFECTED ENGINE………………..…………………..IDENTIFY (NOTE 1&2)

4. *Affected engine*:
FFCL………………………………………………………..…..ADJUST AS REQUIRED
Final approach or hover:
FFCL…………………………………………………..….…………SET 15-20% TQ
On touch down
FFCL………………………………………………………………………..CLOSED

Note 1:
Engine which responds is good engine or

Vary collective as required until POWER 1 or POWER 2 light illuminates

Note 2:
If Ng oscillations, slowly retard FFCL in turn. When FFCL of affected engine is retarded, oscillations will stop."

The company wrote a report after the incident. This included the following recommendation:

> "As a result of this incident, the Operational Department will focus more on engine troubleshooting related to engine failure in flight and will implement more relevant training in the simulator."

COMMENTS FROM THE AIRCRAFT ACCIDENT INVESTIGATION BOARD/ NORWAY (AAIB/N)

The problem with the left engine became a serious incident because the crew reduced the power on the wrong engine in response to the observations they had made. As a result the helicopter were almost without engine power for a period of time. The AAIB/N is of the opinion that the possibility of engine failure cannot be avoided. Safety must therefore depend on making sure that flying can proceed in a satisfactory manner with the one engine that is still functioning properly.

This incident highlights a problem that is commonly present when two engines are connected to a common gearbox. The challenge lies in ascertaining whether the one engine is failing in such a way as to place a greater load on the other engine, or whether one engine is taking on too great a load because a fault in that engine makes the other engine 'redundant'. In this incident it was the right engine that gave the most conspicuous and divergent indications. In the opinion of the AAIB/N, this was partly because the torque indicator in the 'normal position' only indicates the torque for the right engine separately (indicator needle no. 1 then indicates the total torque for the right and left engines). Even if the right and left engines each vary as much as the other, the variations will appear to relate only to the right engine, and the variations on the left engine will be hidden until the indicator is set to the 'crosshatched' position. It was therefore natural for the crew first of all to suspect that the right engine was causing trouble. Experiences from similar situations have shown that it is difficult to leave the initial conclusion, especially when the subsequent information is confusing. In this case, the pressure to make a fast decision was increased by the noises indicating that something serious was about to happen to an engine. The AAIB/N also believes that knowledge of the sudden and uncontrolled overspeeding of the turbine on the helicopter that crashed into the sea at the Norne Field in 1997 could have influenced the Pilot-in-Command's decision to reduce power on the engine that was increasing its RPM, before concentrating on the engine with a sinking RPM. An examination of the information obtained from the CVR and FDR shows that the crew was at times confronted by a large number of warnings and alarms, which could have had a very confusing effect.

The most relevant checklist for this situation, ‘Engine Governor Malfunction’, assumes that the warning light ‘DIFF NG’ comes on and that the Ng is varying. During this flight, it was discovered that something was wrong without this light coming on, and the above-mentioned checklist is based on a situation where the problem is associated with the engine governor. The failure that caused this incident was associated with the engine and not with the engine governor, meaning that the checklist only partially covered this eventuality. The AAIB/N believes that such situations best can be handled by crews with theoretical understanding combined with practical experience acquired with the help of a simulator.

The information that the magnetic plugs were inspected 30 minutes before the incident indicates that the last flight could not have been prevented even if the plugs had been connected to warning lights. The fact that large quantities of metallic particles were found on some of the plugs after the incident, tells the AAIB/N that warning lights might have helped the crew in identifying which engine was failing. This would have made the situation less critical.

This incident has shown that the HUMS, as installed in this particular helicopter, was not capable of detecting this problem.

RECOMMENDATIONS

The AAIB/N recommends the company to set up a training programme to improve the crew’s skill in dealing with engine problems on the Eurocopter AS 332 Super Puma (Recommendation 38/2000).

The AAIB/N recommends the Civil Aviation Authority of Norway (CAA/N) in co-operation with the aviation authorities in France to assess whether it should be mandatory to install magnetic plugs with warning lights in all civil Eurocopter AS 332 Super Puma aircraft (Recommendation 39/2000).