Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A11C0079

ENGINE POWER LOSS – FORCED LANDING
EXPEDITION HELICOPTERS INC.
EUROCOPTER AS 350 B-2 (HELICOPTER), C-GSSS
BUTLER LAKE, ONTARIO
27 MAY 2011

Canada

Aviation Investigation Report

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Synopsis

The Expedition Helicopters Inc. Eurocopter AS 350 B-2, (registration C-GSSS, serial number 2983) was transporting drilling and seismic personnel from the Butler Lake, Ontario, seismic site to the exploration base camp at Straight Lake, approximately 80 nautical miles east of Big Trout Lake, Ontario, with a pilot and 4 passengers on board. Shortly after leveling off at an altitude of 800 feet above ground, the pilot felt 2 yaw kicks in the rudder pedals which were accompanied by a rotor overspeed warning horn. These were followed by a total loss of engine power and a low rotor rpm warning horn. The pilot initiated an autorotation. The helicopter landed hard in shallow water near the shore of a lake. The tail boom and tail rotor were substantially damaged but all occupants exited the helicopter safely and waded to shore. The pilot and 2 of the rear seat passengers were not injured. The other 2 passengers had minor injuries. There was no post-crash fire. The emergency locator transmitter activated as a result of the impact. The accident occurred in daylight hours at 1900 Central Daylight Time.

Ce rapport est également disponible en français.

Other Factual Information

History of Flight

At approximately 1800 [1] the occurrence aircraft departed the Straight Lake exploration camp for a routine daily pick-up of drilling and seismic personnel. Two drillers were picked up at the Straight Lake drill site, then 2 seismic personnel were picked up at the Butler Lake seismic site located at North 52 45 50.3 West 86 48 00.1. On departure from Butler Lake back to Straight Lake, the aircraft was initially flown at a low altitude. Then a steep climb was initiated, followed by a rapid level-off at 800 feet above ground level (agl). Shortly after levelling off, the aircraft experienced 2 yaw "kicks" which were accompanied by a rotor overspeed warning (intermittent horn). These yaw kicks were followed by a total loss of engine power and a low rotor rpm warning (steady horn). The pilot briefly scanned the instruments then initiated an autorotation. He was unable to reach the intended landing area and landed near the shoreline of a small lake.

Egress was unhampered, and all persons on board exited the aircraft after touchdown. The pilot contacted Expedition Helicopters by satellite phone following the occurrence and then turned off the emergency locator transmitter (ELT). Expedition Helicopters arranged for pick-up and transportation of the pilot and passengers to Pickle Lake for medical assistance.

Pilot

The pilot held a Canadian commercial helicopter pilot's licence, with a valid category I medical certificate. He had accumulated approximately 10 000 hours of helicopter flight experience, with 3000 total flight hours on the AS350. According to available information, he was fit and qualified to act as pilot-in-command on the day of the occurrence. There is no indication that fatigue was a factor in this occurrence.

Weather

The nearest weather information was recorded by an automated weather observation station (AWOS) at Big Trout Lake, Ontario, approximately 80 nautical miles west of the occurrence site. At the time of the occurrence, the Big Trout Lake AWOS reported: wind calm, visibility 9 statute miles, a few clouds at 8800 feet agl, temperature 14.8°C, dew point -0.9°C, and altimeter setting 29.79 inches of Mercury. Weather was not considered a factor in this occurrence.

Aircraft

The Eurocopter AS 350 B-2 helicopter, powered by a single Honeywell LTS101-700D-2 turbine engine (serial number LE-46185C), was designed to carry a pilot and 5 passengers. The occurrence helicopter was originally equipped with a Turbomeca Ariel engine; however, in 2008

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[1] All times Central Daylight Time (Coordinated Universal Time minus 5 hours)

it was replaced with the Honeywell engine in accordance with the Transport Canada approved Soloy Aviation Ltd. supplemental type certificate, number SR01647SE.

Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. A review of the technical records indicates that there were no deferred or outstanding defects on the helicopter. The pilot did not report any technical difficulties with the aircraft before the occurrence. At the time of the occurrence the helicopter had approximately 90 imperial gallons of fuel on board.

Pilot-selected rotor rpm is achieved by a throttle lever mounted on the rotor pitch collective lever. Rotor rpm and engine speed are maintained by the engine's power turbine (PT) governor. The PT governor is designed to maintain 100% PT rpm (Np) $\pm$ 1% or 390 +4 or -5 rotor rpm (Nr).

Rotor and engine overspeed protection are provided by an electronic engine overspeed protection system (EOS). Np is monitored through engine-mounted magnetic pickups and sent to an EOS controller (Autronics part number (PN) 91547-SOCN-4-301-483-02). When a PT rpm speed of 109% Np is detected, the EOS controller actuates a solenoid which reduces fuel flow. As the PT rpm decelerates to 106% Np, the EOS controller deactivates the solenoid and fuel flow is restored. If the conditions that produced the overspeed are still present, the PT rpm will again accelerate to 109% and the EOS will reactivate. This type of EOS cycling can continue until the pilot assumes manual control of the fuel flow. In the event that EOS cycling (PT governor failure) is encountered, the AS 350 flight manual directs pilots to control rotor rpm with collective control and to land as soon as possible.

The helicopter is equipped with a main rotor speed aural warning system. A continuous horn sounds when the main rotor speed is below 360 rpm and an intermittent horn sounds when the main rotor speed is above 410 rpm.

Engine

The Honeywell LTS101-700-D-2 engine has a history of power losses related to 2 specific areas:

- The power turbine governor spool bearing PN 2523973N; and
- The fuel pump inducer jet orifice

The LTS-101-700-D2 engine is equipped with a Honeywell PT governor (PN 4-301-289-05). This PT governor was originally designed to have an overhaul life of 2400 hours. The PT governor incorporates a spool bearing (manufactured by Timken Aerospace), which is a sealed ball bearing that is lubricated with grease at the factory. The spool bearing supports the drive shaft and fly-weight assembly inside the PT governor. To date there have been 10 failures of the PT governor spool bearing. As a result of these failures, Honeywell has issued service bulletins that have recommended replacing this bearing at earlier intervals [2] Information provided by the manufacturer indicates that these failures were the result of hard-particle contaminants

[2] Honeywell Service Bulletin (SB) GT-73-351

remaining in the bearing race after assembly. It was also reported that inspections of other spool bearings manufactured between 2006 and 2008 have revealed similar contaminants.

The occurrence aircraft's engine fuel pump was equipped with a 0.132-inch diameter inducer jet orifice. Information provided by the manufacturer indicates that there is a history of EOS-induced flameouts [3] associated with the 0.132-inch inducer valve jet orifice originally installed in LTS101 engine fuel pumps. EOS activation or cycling can result in a momentary surge of bypass fuel producing a higher pressure on the unmetered side of the minimum pressure valve within the fuel control unit (FCU). As a result, the minimum pressure valve closes, reducing the fuel flow, which in turn can lead to a flameout and loss of engine power.

Research and field testing conducted by Honeywell indicates that increasing the diameter of the inducer jet orifice in the fuel pump will reduce the pressure across the unmetered side of the minimum pressure valve in the FCU. This prevents the minimum pressure valve from closing and eliminates the risk of engine flame-out associated with EOS activation.

The EOS controller module from the occurrence aircraft was tested and found serviceable.

Wreckage

TSB investigators were unable to deploy to the accident site. Following the occurrence, the wreckage was transported to the operator's maintenance facility for further inspection. Upon arrival at the operator's maintenance facility, a Transport Canada inspector witnessed the removal and crating of the engine. Shortly afterward Transportation Safety Board investigators confirmed that the nature of the damage observed at the maintenance facility was consistent with photographs taken at the site shortly after the occurrence.

The occurrence aircraft's engine was shipped to a test facility. Before running the engine, the engine's chip detectors, engine bleed air (Py) circuit, and filters were examined and no apparent pre-existing anomalies were detected. It was determined that the engine was in suitable condition for running in the test cell. The engine was then test run with all the original components installed, including the PT governor, fuel pump, and FCU. The test cell incorporated the use of water-brake type dynamometer (dyno) brake.

The test run revealed that with the application of power, under no-load conditions, the power turbine speed (Np) would exceed the specified governing speed of 100%. With the dyno brake off, the engine was allowed to accelerate to produce 109% Np, at which point it was concluded that there was a failure of the PT governor and the engine was then shut down. The original PT governor was then replaced with an overhauled unit and the engine was run again. With the overhauled PT governor in place, the engine was accelerated to produce 100% Np, which it would not exceed with further application of throttle, indicating a functioning PT governor. No other anomalies were noted with the engine during the test runs.

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[3] The history of EOS-induced flameouts occurred during ground testing of the EOS system at various rotor rpm settings.

The PT governor that had been removed from the occurrence aircraft's engine (Honeywell, PN 4-301-289-05, serial number 84490007) was taken to a Honeywell facility for teardown. Disassembly of the PT governor revealed that the spool bearing (PN 2523973N) had failed and was completely destroyed. The spool bearing remains were secured and sent to the TSB Laboratory for further analysis. The spool bearing in the occurrence aircraft failed at 228 hours total time since new. The analysis of the failed occurrence spool bearing, completed by the TSB Laboratory, was consistent with the analysis performed by Honeywell on previous failed spool bearings. Photo 1 below shows the PT governor after removal from the engine at the test facility, and the debris found in the PT governor drive body after disassembly.

Photo 1. Bearing debris in PT governor (red circle)

Examination of the spool bearing's raceways and balls revealed several microscopic diamond particles, deteriorated lubrication properties, and oxidation spots. The microscopic diamond particles are believed to have been left in the bearing's components after the cleaning process, before assembly. Interference of diamond particles between the inner race and balls will result in abrasive wear of the bearing that will increase friction and produce elevated temperatures of the affected components. The elevated temperatures will result in a breakdown of the lubrication qualities of the grease. Continued operation of the bearing in this state will eventually result in failure. A total of 55 days had elapsed between the time of the occurrence and the spool bearing examination. During that time, the spool bearing remains were exposed to ambient conditions. Bearing material that has been subject to such a failure can produce oxidation spots after exposure for a prolonged period of time.

TSB Laboratory Reports

The following TSB laboratory report was completed:

LP 083/2011 – Spool Bearing Examination

This report is available from the TSB upon request.

Analysis

The aircraft's PT governor spool bearing failed after only 228 hours of operation. Microscopic diamond particles were found in the remains of the PT governor spool bearing. Consequently the analysis of the spool bearing failure focussed on how the particles could have led to its failure. Their presence would have resulted in excessive friction and heat between the bearing's surfaces. The excessive heat would have deteriorated the lubrication qualities of the grease. This combination of factors likely led to the failure of the bearing. It is likely that the delay between the occurrence and the spool bearing examination allowed the raceways and balls to produce the oxidation spots noted on the bearing remains after the occurrence. Lack of lubrication and oxidation are therefore not considered to have initiated the bearing failure.

Aircraft equipped with a Honeywell PT governor (PN 4-301-289-05) with the affected spool bearings manufactured between 2006 and 2008 have an increased risk of engine power loss, associated with a failure of the spool bearings.

The engine's PT governor spool bearing likely failed shortly before or just as the aircraft levelled off after departure from Butler Lake. When the aircraft levelled off rapidly, the load on the rotor disc would have decreased briefly. This decrease in load on the main rotor would result in a tendency for the rotor to overspeed. With a failure of the PT governor, the engine would have oversped and activated the EOS system. This would have produced the first yaw kick to the left and the intermittent (rotor overspeed) warning. As the engine speed increased to 109% Np the EOS system would have tripped and signalled the FCU to vent and reduce fuel flow to decelerate the engine. When the Np dropped to 106%, the EOS repeated the cycle and the Np increased back to 109%. This produced the second yaw kick to the left. During the second cycle of the EOS, restricted fuel bypass associated with the 0.132-inch inducer jet increased fuel pressure across the unmetered side of the minimum pressure valve. As a result, the minimum pressure valve was forced closed, reducing the fuel flow at the fuel outlet of the FCU. This resulted in an engine power failure and a continuous horn (low rotor speed) to sound.

The pilot was compelled to initiate autorotation. The aircraft landed hard in shallow water, leading to substantial aircraft damage and minor occupant injury.

Findings as to Causes and Contributing Factors

1. Diamond particles in the aircraft's PTG spool bearing likely caused the bearing to fail, at approximately 228 hours total time since overhaul. The failure of the spool bearing resulted in a failure of the power turbine governor.

2. The failure of the power turbine governor allowed the engine and rotor to overspeed as the helicopter levelled off, which activated the helicopter's engine overspeed protection system and caused it to cycle.

3. The engine overspeed protection system–induced engine cycling combined with the increased fuel pressure produced by the 0.132-inch inducer jet likely caused the engine to flame out.

4. The aircraft landed hard in shallow water, leading to substantial aircraft damage and minor occupant injury.

Findings as to Risk

1. Aircraft equipped with Honeywell LTS101-700-D-2 engine with power turbine governors fitted with affected spool bearings have an increased risk of PT governor failure.

2. AS 350 B-2 helicopters equipped with Honeywell LTS101-700-D-2 engines fitted with engine fuel pumps equipped with 0.132-inch diameter inducer jets are at increased risk of engine flameouts resulting from the cycling of the engine overspeed protection system.

Safety Action Taken

Transportation Safety Board of Canada

On 06 October 2011, the TSB issued Aviation Safety Advisory A11C0079-D1-A1, Honeywell LTS101-700-D-2 Power Turbine Governor Spool Bearing Failure. The advisory highlights the risks associated with failure of the power turbine governor spool bearing, and urges Transport Canada to take action to require the affected bearing to be replaced, and take urgent action that would make mandatory the requirements set forth in Honeywell Service Bulletin GT-73-A359.

On 06 October 2011, the TSB issued Aviation Safety Advisory A11C0079-D2-A1, Honeywell LTS101-700-D-2 Engine flameout associated with engine overspeed system (EOS) activation. The advisory illustrates the continued risk of in-flight engine flameouts as a result of EOS activation associated with the affected fuel pumps, and indicates that crews and aircraft will continue to be placed at risk until operators of LTS101-700-D2-equipped aircraft replace the 0.132-inch fuel pump inducer jet orifice with a 0.165-inch diameter inducer jet orifice.

Federal Aviation Administration

On 14 November 2011, the United States Department of Transportation, Federal Aviation Administration, issued Airworthiness Directive (AD) 2011–23–13. This AD requires initial and repetitive replacements of power turbine governor models AL–AB1, P / N 4–301–289–03, 4–301289–05, 4–301–289–09, 4–301–101–16, and 4–301–101–18 marked with compliance symbol N or P, or with no compliance symbol, on the power turbine governor identification plate. The AD was effective 29 November 2011. Transport Canada requires that any AD issued by the state of manufacture must be complied with by all affected operators of the aeronautical product.

Honeywell International Inc.

On 23 August 2011, Honeywell issued Service Bulletin GT-73-359 which recommended the replacement of bearings PN 2523973 at 200 hours and bearings PN 252973P at 900 hours.

Honeywell, in conjunction with Timken Aerospace, have implemented improved manufacturing processes ensure that diamond particles are removed from the spool bearings before assembly.

On 08 February 2012, Honeywell issued an Operational Information Letter No. OIL T1 01-04 providing operators advice about symptoms in case of PTG spool bearing malfunction and asking pilots to refer to the flight manual in such an occurrence.

Timken Aerospace

Timken Aerospace, in conjunction with Honeywell International Inc., has implemented improved manufacturing processes to ensure that diamond particles are removed from the spool bearings before assembly.

In April 2011, Timken Aerospace ceased shipment of spool bearings PN 2523973 with the lettered suffix N.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 04 July 2012. It was officially released on 02 August 2012.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.