AVIATION OCCURRENCE REPORT

ENGINE POWER LOSS - MECHANICAL MALFUNCTION

SKYTECH AVIATION LTD.
BELL 206B JETRANGER (HELICOPTER) C-GXNM
DRYDEN, ONTARIO 4 mi NW
07 JULY 1995

REPORT NUMBER A95C0149

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

The pilot and sole occupant of a Bell 206B helicopter, C-GXNM (serial number 1111), was conducting a visual flight rules (VFR) flight from Dryden to Red Lake, Ontario. This was the first leg of a journey that would transport the pilot and equipment to a contract in the Northwest Territories. The start-up and climb-out were normal, and the pilot had established the helicopter on course at 2,500 feet above dense trees and a river. There was a loud but muffled bang near the rear of the helicopter. The aircraft lurched, and the engine-out warning sounded. The pilot commenced an autorotation to a clearing approximately one-half mile to his left. As he approached the clearing, he realized that the rate and angle of descent would result in the helicopter landing in a flooded area, unsuitable for landing, so he extended the glide to reach the field. The helicopter touched down with a forward speed of 10 to 12 miles per hour and pitched tail-up as it slid to a stop in an upright attitude on the high skid gear. The tail boom and tail rotor assembly were severed from the helicopter by the main rotor blades. The pilot was not injured.

Ce rapport est également disponible en français.

Other Factual Information

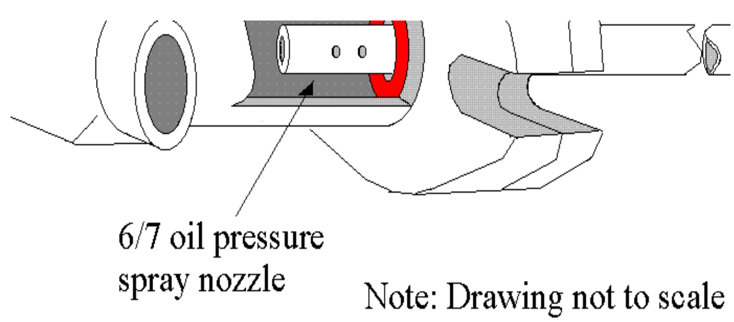
The engine failure occurred approximately seven minutes into the first flight after the completion of the 300-hour inspection. The engine had exhibited normal temperatures and pressures during the initial phases of the flight, and there were no warning indications prior to the engine failure. When the engine failed, the helicopter yawed and the engine-out warning sounded.

The engine was removed from the helicopter, and a preliminary teardown determined that the effects of oil starvation of the number 6 and 7 bearings resulted in heat damage to adjacent components and a decoupling of the turbine and compressor sections of the engine. The power turbine scavenge sump was dry, and no ferrous material had transferred to the chip detectors to warn of the impending engine failure. The partially disassembled turbine and oil samples from the engine were forwarded to the TSB Engineering Branch for detailed analysis.

The oil samples were analyzed by the TSB and by the engine manufacturer. The oil was determined to be the correct type and did not appear to have been contaminated; however, there was evidence that the oil had been exposed to high temperatures. It was not possible to determine if anti-foaming additives were present.

A connector assembly (part number 6848194C), commonly referred to as the tee-fitting, supplies pressure oil to the number 6/7 bearing pressure oil nozzle and to the pressure oil supply line for the number 8 bearing. The inlet to the tee-fitting is protected by a filter screen. At installation, the upper portion of the 6/7 bearing pressure oil nozzle is inserted into the base of the tee-fitting, producing a standpipe inside the tee-fitting. As a result, a recess is formed between the standpipe and the inner walls of the fitting. (See Figure 1.)

The TSB Engineering Branch determined that the 6/7 bearing pressure oil nozzle was blocked by a particle of hard carbon. A piece of hard carbon was also found in the oil supply line for the number 8 bearing. Both carbon particles were too large to have passed through the inlet screen of the tee-fitting. Inspection of the tee-fitting revealed a build-up of hard carbon in the area between the standpipe and the inner wall at the base of the tee-fitting. The degree of carbon build-up was excessive for the time-in-service since the DIL 155 inspection. Using the electron scanning microscope (SEM), a sample of the carbon taken from the base of the



tee-fitting was compared with the carbon particles. It could not be conclusively determined that the two particles had come from the base of the tee fitting; however, the carbon particle from the pressure nozzle displayed a uniform curvature with a radius that matched the radius of curvature of the interior passageway of the base of the tee-fitting. Energy dispersive X-ray analysis of the three carbon particles showed that they were probably derived from the same combusted material and/or combustion reaction. The carbon particle that blocked the 6/7 bearing pressure oil nozzle most probably originated in the base of the tee-fitting.

Allison Gas Turbine/General Motors Corporation publishes the procedures by which the engine is to be maintained and overhauled. The 100-hour inspection specified in the C20 Operations & Maintenance Manual requires accomplishment of a scavenge flow check from the external sump. If the oil flow from the external sump does not meet 90cc minimum flow, the 6 and 7 bearing pressure oil nozzle, the tee-fitting and filter screen, the scavenge oil strut, and the external scavenge sump must all be cleaned. Additionally, these components must be cleaned at each 300-hour inspection. The procedure for cleaning the pressure oil tee-fitting (O&M Manual, Para 3-184 d.) requires insertion of a number 12, 0.189-inch drill bit into the pressure oil outflow port at the base of the tee-fitting.

The Allison 250-C20 Overhaul Manual calls for the pressure oil nozzle and tee-fitting to be cleaned in an alkaline bath at each overhaul. In distributor information letter (DIL 155) revision 7, dated 28 February 1990, Allison Gas Turbine Division provides the prescribed procedures for accomplishment of a recommended 1,750-hour scheduled turbine heavy maintenance inspection. One of the items of this procedure requires the inspection of all oil nozzle passages and bearing sumps for excessive carbon formation and/or obstructions. The overhauler is directed to clean as necessary.

Essential Turbines Ltd. completed a 1,750-hour heavy maintenance inspection of a turbine (part number 6898735, serial number 33272), in accordance with the DIL 155 procedures. As part of that inspection process, the inlet screens and the pressure tee-fittings for the number 6, 7, and 8 bearings were cleaned using prescribed procedures. The turbine had been received from, and was returned to, Skytech Aviation Ltd., without an external sump installed. The turbine was then installed in the Allison 250-C20B engine (serial number 37173) on Skytech's Bell 206B helicopter, C-GXNM, at an airframe time of 8,585.8 hours. A used but serviceable sump can was inspected, cleaned, and installed by the operator. At 12.8 flight hours after the turbine installation, the engine exhibited smoke from the exhaust.

At the request of the operator, the overhaul agent completed an in-the-field change of the number 5 carbon seal. When the turbine section was removed and inspected, the power turbine support scavenge strut was almost completely blocked with carbon, and carbon had also accumulated in the sump can. The engine oil reportedly was dark but did not smell burned. The overhaul agent changed the number 5 carbon seal and cleaned out the external sump can, and the operator's apprentice engineer cleaned out the scavenge strut. The overhauler visually inspected the scavenge strut to confirm it was clean, and re-installed the turbine. The engine oil filter was cleaned, and the engine oil system was replenished with new oil. The 6/7 bearing pressure oil nozzle and tee-fitting assembly was not removed during the scavenge strut cleaning. The engine was motored over to ensure a positive oil flow. During an extended ground run, the engine started normally, did not smoke or leak, and spooled down normally. The next day the operator flew the helicopter to Dryden, a flight duration of 0.9 hours.

At Dryden, while conducting a 300-hour inspection, the operator found evidence of an oil leak in the engine compartment. While assessing the leak source, he pulled and re-installed the turbine, and conducted several extended ground runs. The leak was eventually rectified by replacement of a free-wheeling unit. The helicopter had flown less than 14 hours since the turbine inspection, and approximately one hour since the scavenge strut had been cleaned and the engine oil replaced. Therefore, the operator did not conduct a scavenge flow test and did not accomplish the 300-hour inspection items involving the cleaning of the 6/7 bearing pressure-oil and scavenge-oil components.

A review of the inspection and cleaning procedures for the tee-fitting indicated that existing published procedures for inspection and overhaul may not ensure adequate cleaning of carbon build-up in the area of the recess inside the base of the pressure oil tee-fitting. Immersion in an alkaline bath during overhaul and reaming the outflow passage with a drill bit during field cleaning may not ensure that all carbon is removed. Carbon build-up in the base of the tee-fitting is difficult to inspect because it faces away from the inspection access -- the outflow port at the bottom of the tee fitting -- and current inspection procedures do not outline how to access the hidden area to confirm that the area is clear of carbon.

The engine manufacturer indicates that, even if coke/carbon does form in the tee-fitting passage, the design of the standpipe, with its laterally drilled inlet holes, and the proper accomplishment of the inspection procedures as outlined in the maintenance and overhaul manuals should prevent carbon build-up and subsequent inlet blockage. The manufacturer states that a review of the failure history for the 250-C20 series engines does not indicate an inherent design problem. The manufacturer attributes no failures to clogged inlet holes of the pressure oil nozzle on the existing 14,400 engines that have accumulated a total flight time of 60,200,000 hours. The manufacturer estimates that an engine would fail within five minutes or less if its 6/7 bearing pressure oil nozzle became blocked.

TSB investigators inspected a sample of four turbines in "as-received" condition at an independent overhaul facility. In three of the four turbines, carbon build-up was confirmed inside the base of the tee-fittings. The three turbines that displayed carbon build-up in the tee-fitting had been in service for 1,000 hours or more since their last overhaul. The fourth turbine had been in service less than 500 hours since overhaul. The 6/7 bearing pressure oil nozzles in all four sampled turbines were clear of obstruction.

Analysis

There was substantial heat damage in the engine that indicated there was no oil flow beyond the 6/7 bearing pressure oil nozzle. The bearings had run dry, and there was slight carbon residue in the scavenge strut and sump; however, no ferrous material had been transported downstream to the magnetic chip detectors. This indicates that the engine failure occurred as a result of restricted oil flow from a complete blockage, rather than a partial blockage of the 6/7 bearing pressure oil nozzle.

The design of the tee-fitting and standpipe assembly is conducive to the formation of carbon between the inner wall of the tee-fitting and the standpipe of the 6/7 bearing pressure oil nozzle, where oil becomes trapped. A hard carbon deposit had built up in this area of the tee-fitting. The carbon build-up was considered excessive for the hours of operation since the completion of the heavy maintenance inspection.

The carbon particle which blocked the 6/7 bearing pressure oil nozzle displayed characteristics similar to the composition of the carbon that had formed inside the base of the tee-fitting, and the particle had a uniform curved surface that compared with the inside diameter of the tee-fitting wall. Therefore, it is likely that the carbon originated in the tee-fitting, then broke loose and moved to block the nozzle. Although the manufacturer's data indicate that build-up of carbon in this area has not previously resulted in engine failure, it is concluded that it likely did in this case.

An inspection of pressure oil connector tee-fittings from four independent turbines revealed that carbon deposits had formed in the base of three of the four tee-fittings. The three tee-fittings had been in service for 1,000 hours or more; therefore, they would have been subjected to the drill-cleaning procedures outlined in the manufacturer's 300-hour inspection three or more times.

The current inspection and cleaning instructions may not ensure complete removal of carbon from the recessed area inside the base of the tee-fitting. Solvents may not dissolve all carbon, and reaming of the outflow port with a hand-held drill bit will not reach the area that needs to be cleaned. Considering the degree of carbon build-up in the base of the tee-fitting and the short operating time since accomplishment of the DIL 155 inspection, it is probable that the carbon was not fully removed during the overhaul process.

The following Engineering Branch reports were completed:

LP 103/95 - Engine Examination; and
LP 106/95 - Oil Sample Analysis.

Findings

1. The engine began making smoke 12.8 flight hours after the overhauler completed a turbine heavy maintenance (DIL 155) inspection/overhaul.

2. The overhauler and the operator's apprentice replaced the number 5 carbon seal, removed carbon from the scavenge strut and from the scavenge sump, and motored the engine to ensure that adequate oil flow was provided to the sump, but did not remove and clean the 6/7 oil pressure nozzle and tee-fitting as specified in the manufacturer's Operating and Maintenance Manual.

3. The turbine had been overhauled less than 14 flight-hours earlier, and the scavenge strut had been cleaned within the last flight-hour. The operator did not complete a power turbine scavenge flow test and did not remove and clean the pressure oil and scavenge components, as outlined in the 300-hour inspection procedures.

4. A build-up of hard carbon in the tee-fitting of this engine was considered excessive for the hours of operation since the completion of the heavy maintenance inspection. It is probable that the carbon was not fully removed during the overhaul process.

5. A particle of carbon blocked the 6/7 bearing pressure oil nozzle, and the engine failed as a result of the lack of lubrication and the excessive heat damage in the vicinity of the number 6 and number 7 bearings.

6. It is likely that the hard carbon that blocked the oil flow originated in the tee-fitting.

7. The design of the tee-fitting and standpipe assembly is conducive to the formation of carbon in an area between the inner wall of the tee-fitting and the 6/7 bearing pressure oil nozzle.

8. The manufacturer's procedures do not specifically identify the area within the base of the tee-fitting in which carbon builds, nor do the procedures identify how to inspect this area that is hidden from view.

9. Tee-fittings from three of four independent turbines that were inspected had developed carbon deposits in the base of the tee-fittings, although they would have been subject to cleaning three or more times during 300-hour inspections.

Causes and Contributing Factors

The engine failed in flight because of a lack of lubrication to the number 6 and 7 bearings when a carbon particle blocked the 6/7 bearing pressure oil nozzle. Contributing to the presence of the carbon build-up were the following: a tee-fitting and standpipe design that is conducive to carbon accumulation; a manufacturer's cleaning procedure that does not completely describe the carbon inspection and removal process; inadequate cleaning of the tee fitting during component overhaul; and incomplete cleaning during two subsequent field inspections.

Safety Action

An Aviation Safety Information letter was sent to TC outlining the particulars of the carbon build-up inside the base of the pressure oil tee-fitting as identified during this investigation.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, Benoît Bouchard, and members Maurice Harquail and W.A. Tadros, authorized the release of this report on 27 August 1996.