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Failure analysis of a bearing in a helicopter turbine engine due to electrical discharge damage

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ABSTRACT

This article documents the metallurgical evaluation of a rolling element bearing that failed due to electrical discharge damage. This rolling element bearing was used in a helicopter turbine engine that failed in-flight, resulting in a hard landing of the helicopter. Optical and electron microscopy as well as energy dispersive spectroscopy were used to evaluate the bearing. Pitting and material transfer on the external bearing races bearing and mating surfaces revealed that the electrical discharge damage occurred while the engine's components were not rotating.

1. Introduction

On January 08, 2010 a Hughes 369D helicopter, experienced a loss of engine power and landed hard in the wilderness near Kooskia, Idaho [1]. The pilot further reported that a chip detector light illuminated for several seconds about one hour prior to the accident.

The Hughes 369D, serial number 470120D, was manufactured in 1977, and had accrued a total time in service of about 13,197 h at the time of the accident. The last airframe inspection occurred in December, 2009, about 30 h of flight prior to the accident. The helicopter was equipped with a Rolls-Royce/Allison 250-C20B turboshaft engine, serial number CAE-833319, rated at 420 shaft horsepower (SHP). The engine had accumulated a total time in service of 7241.9 h and had undergone a gearbox repair in October 2009, with the engine being reinstalled on the airframe in November, 2009.

The Rolls-Royce/Allison 250-C20B is a two-shaft turboshaft engine with a combination compressor, which consists of a six-stage axial compressor attached to a one-stage centrifugal compressor. The engine incorporates a reverse-flow annular combustor, a two-stage high-pressure turbine (also referred to as the N1 gas producer turbine), and a two-stage low-pressure turbine (also referred to as the N2 power turbine). The gas path along the engine flows into the inlet, through the compressor's axial and centrifugal stages, into two external air transfer tubes and to the combustor, which is located at the

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very rear of the engine. The gases then turn 180° toward the front of the engine and proceed through the two-stage gas producer turbine (N1) and the two-stage power turbine (N2). Finally, the gases are directed out of the exhaust collector and upward through two exhaust outlets.

N1, consisting of turbine wheels and nozzles #1 and #2, drives the compressor section of the engine through an inner shaft, while N2, consisting of turbine wheels and nozzles #3 and #4, drives the power output gear (to the main rotor transmission) and the accessory gearbox through an outer shaft. The inner shaft rotates independently within the outer shaft.

The engine's compressor assembly, part number (P/N) 6890550 had accumulated 301.9 h since overhaul and was installed in the accident helicopter in June 2009, about 6 months prior to the accident.

2. Investigation

2.1. Airframe examination

The fuselage sustained significant damage with most damage on the left side. The aft compartment floor was pushed upward approximately 200 mm on the left side. There were multiple main rotor blade strikes to the tail boom, which was separated at fuselage station 240. Examination of the flight control system revealed no evidence of mechanical malfunction or failure. The visual inspection of the fuselage and airframe components during the wreckage inspection did not detect any burn marks, arcing, pitting, or signs of high temperatures stress associated with electrical arcing.

2.2. Engine examination

External examination of the engine revealed that it had sustained crush damage to the combustor case. A speed handle was inserted into the N1 and N2 tachometer drive pads on the gearbox housing. Rotational continuity was established for the N2 gear train and it was found to rotate freely without binding. During the attempted rotation of the N1 gear train, binding was detected. The engine chip detectors were found to contain many metal particles imbedded.

Further disassembly revealed that the No. 2 bearing, P/N 6889093AL, ball retainer was fractured. The ball bearing retainer was separated in two locations and numerous balls within were gouged on their surface and deformed. A thin oil film was present and no noticeable discoloration was observed. The shim and oil slinger were intact. A review of the records revealed that during the overhaul, a new No. 2 bearing was installed: P/N 6889093AL, serial number (S/N) TA 36-0510763.

The compressor case halves were removed, revealing that the rotor assembly was intact with no evidence of damage observed. The diffuser scroll exhibited circumferential rubbing, consistent with the impeller blades making contact. The

Fig. 1. Picture of the as-received No. 2 bearing pieces, oil slinger, shims, retaining ring, and spanner nut as identified in the following list: (1) oil slinger, (2) shims, (3) No. 2 bearing piece (outer race, retainer pieces, and two balls), (4) No. 2 bearing inner race halves, (5) eleven bearing balls, (6) bearing retainer pieces, (7) retaining ring, (8) spanner nut.