AVIATION OCCURRENCE REPORT

ROLL-OVER ON LANDING

ALPINE HELICOPTERS LIMITED
BELL 212 (HELICOPTER) C-GALI
MICA CREEK, BRITISH COLUMBIA 3NM SW
01 MARCH 1997

REPORT NUMBER A97P0044

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Summary

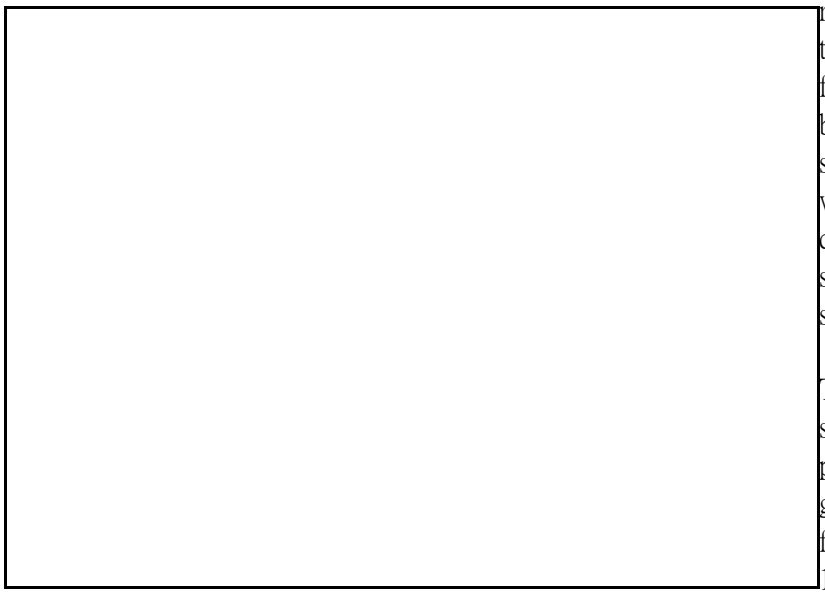
At about 0830 Pacific standard time, the Bell 212 helicopter (serial number 30525) with the pilot, 11 passengers, and the ski-guide on board, was on approach to a prepared landing site in the Monashee Mountains near Mica Creek. About 200 feet from touchdown, the occupants heard a loud explosion and saw several cockpit warning lights illuminate; simultaneously, the number 1 engine stopped. The pilot continued the approach, but the low rotor rpm warning horn came on and the helicopter turned gradually to the right, forcing the pilot to land in an adjacent, unprepared area. The passengers reported that the initial touchdown was not hard, but the helicopter then tipped over onto its left side in the waist-deep snow, and the main rotor blades struck the surface. The main transmission was ripped out, and one rotor blade struck the cockpit roof, severely damaging the overhead electrical circuit breaker panels. The 11 passengers in the cabin quickly evacuated the helicopter without difficulty, using the right-hand sliding door. The ski-guide, who was seated in the left pilot seat, broke open and escaped through the roof window above him. He returned with two other passengers to extract the pilot through the same window opening. Despite the rollover, the number 2 engine continued to run for 15 minutes, when another loud explosion was heard, and this engine stopped. Two small engine bay fires began but quickly self-extinguished. There were no other injuries. The helicopter was substantially damaged. The emergency locator transmitter (ELT) activated during the accident and its signal was received by the SARSAT (search and rescue satellite-aided tracking) network.

Other Factual Information

The pilot was certified, trained and qualified for the flight in accordance with existing regulations. He was on the last day of a two-week tour of duty at the Mica Creek Lodge. The guide and other witnesses reported the weather at the accident site as more than 4 miles visibility in very light snow with an overcast or broken layer of clouds at about 7,500 feet and a light wind from the south. The accident occurred at the 5,500-foot level, about 50 feet from the intended landing site.

The weight and centre of gravity of the helicopter were within the prescribed limits. The manufacturer's performance charts indicate that the helicopter was capable of a single-engine rate-of-climb of 250 feet per minute, given the flight conditions of that day. However, in this instance, the pilot was committed to touchdown because the helicopter was in a slow and shallow descent for a landing when the number 1 engine stopped, and was too slow and too close to the ground to arrest the rate-of-descent with only one engine. In the attempt to continue the approach to the intended site, the main rotor rpm decayed, and the pilot was forced to land at an unprepared site.

On examination, both engines were found to have suffered uncontained power turbine failures. A power turbine wheel, when operating under load, will rapidly accelerate to high speed if it is suddenly uncoupled from that load. The normal maximum rotational speed of the power turbine wheel in the PT6T-3 engine is 33,000 rpm. Pratt and Whitney Canada (P&WC), the engine manufacturer, report that the designed fracture speed for the blades is between 45,700 and 51,600 rpm, and that the blades are designed to fracture in an overspeed situation before the disc speed is high enough to cause it to fail. The number 1 engine power turbine wheel had shed about three-quarters of its blades with the remaining quarter grouped together on one section of the wheel. The number 2 engine power turbine had shed all of its blades. The blades from both wheels broke through their respective steel containment rings, through the combustion cans, and finally through the outer casings of both engines. Although the engine structure did not restrain the blades when they separated from the turbine disk, the blades did not cause further significant damage to the helicopter structure.



The engines were examined, and the shafts connecting each engine's power turbine to the combining gearbox (C-box) were found to have failed. The input shaft for the number 1 engine had failed at the number 5 bearing, located at the front of the C-box. The bearing had disintegrated and the shaft had melted. The shaft for the number 2 engine failed just aft of the power turbine. It was determined that this shaft had failed due to

insufficient lubrication at the number 4 bearing. All bearings in the number 2 engine showed signs of heat distress, the result of insufficient lubrication as the engine continued to run while the helicopter was on its side. The gas-producing sections of both engines turned freely, and no anomalies were found that would have caused either engine to overspeed.

The C-box was dismantled. The clutch assembly for the number 1 engine exhibited extreme wear. The clearance between the outer and inner clutch surfaces was 0.0137 inches beyond tolerance. The engagement surfaces were rough, and there were indications that the clutch had been slipping. According to the clutch manufacturer, a clutch worn to this extent can slip at normal torque loads. The inner shaft's end movement, or float, was measured to be 0.029 inches, well beyond the overhaul standard of between 0.002 and 0.004 inches. Spacing shims within the clutch assembly were also found to be worn and the inner races of the clutch bearings had grooves worn into them.

The coupling shaft between the number 1 engine clutch and the final output helical gears was found to have sheared. The fracture surfaces of this shaft had smeared when the two halves had rubbed against each other after breaking; however, the general characteristics of the failure were consistent with a torsional overload in the direction of normal driving loads.

Analysis by the TSB Engineering Branch determined that the clutch met the manufacturer's specifications for material and hardness. It was found that the grooves in the inner races were caused by wear. When the clutch is engaged, as it is during all normal operations, the outer and inner shafts turn together as one unit, and there is no relative movement of the clutch bearings. Drive system vibrations could cause the stationary ball bearings to wear grooves into the bearing races. The wear on the shims and the grooves in the inner races permitted the inner shaft end float to increase.

Eight days before the accident, the C-box chip detector warning light had illuminated and, on inspection, fuzz and two fine metal slivers were found on the chip plug. The material was removed and retained. The C-box oil and filter were changed, and an engine run was carried out. After the accident, the material removed from the chip plug was analysed by the TSB Engineering Branch and found to be the same material as found in the clutch. The clutches are lubricated by the C-box lubrication system.

Two weeks before the accident, the tail rotor drive shaft experienced an unexplained torque overload that damaged the 90-degree gearbox. As a result, the 90-degree gearbox, the drive shaft, the 42-degree gearbox, and the hanger bearings were replaced. The replacement 90-degree gearbox, which was in the helicopter at the time of the accident, was compared with the gearbox that was involved in the earlier incident; both gearboxes exhibited almost identical damage patterns.

Technical records indicate that the helicopter was maintained in accordance with existing regulations and standards of airworthiness. Since their overhauls, the number 1 engine had accumulated 2,822 hours, the number 2 engine had accumulated 930 hours, and the C-box had accumulated 2,920 hours. The normal time between overhauls for the C-box is 4,500 hours. The C-box was last overhauled at the P&WC service centre in St. Hubert, Quebec, and the maintenance release was dated 27 January 1993.

Several safety measures taken by the company enhanced the survivability of this accident. The company strongly recommended and encouraged its pilots to wear helmets. The pilot's head injuries would have been more severe, and likely fatal, had he not been wearing a helmet. The company ensured that the passengers received a thorough pre-flight briefing and, as a result, egress from the cabin was quick and orderly. The passengers kept their seat belts on until they had firm hand holds and were prepared to climb out of the cabin, and they used the specially painted seat legs as a ladder to climb out of the helicopter, which was on its side.

Analysis

Both engines suffered uncontained failures of the power turbine blades because of failures in the drive train from the engine to the final output shaft. The failures of the input shafts for both engines are considered secondary. The primary failure was the failure of the number 1 engine clutch coupling shaft. This shaft sheared due to the excessive loads placed on it when the worn clutch began to slip and then suddenly re-engaged. The power turbine wheel then oversped sufficiently for the turbine blades to fracture. After it failed, the wheel contained only one-quarter of its blades, and the resulting imbalance placed extreme loads on the number 5 bearing. The number 2 engine continued to run while the helicopter was on its side, and the engine eventually failed because of a loss of lubrication.

No single factor was found that would have caused the clutch to wear. The bearing races probably began to wear while the clutch was engaged, and the ball bearings wore grooves into the races due to drive system vibrations. The grooves would have caused greater stress on the outer race during clutch freewheeling (when there would have been relative motion between the inner and outer races of the bearings), and this would have accelerated the wear in the bearings. The wear on the clutch engagement surfaces may have been caused by contamination from the wear metals of the bearings.

Both the tail rotor system torque overload experienced two weeks before the accident, and the C-box chip light warning experienced eight days before the accident, were likely caused by the wear in the clutch. Although both incidents were investigated by maintenance staff, the maintenance staff did not make a connection between the two events, nor did the symptoms lead them to suspect a clutch malfunction. The operational environment in which the helicopter worked was not unusual, and no operational practice was identified that would have contributed to abnormal clutch wear. Further, there is no significant history of worn or slipping clutches on the Bell 212 helicopter.
The following Engineering Branch report was completed:

LP 38/97 - Combining Gearbox

Findings

1. The pilot was certified, trained, and qualified for the flight in accordance with existing regulations.

2. The maintenance records indicate that the aircraft was certified, equipped, and maintained in

accordance with existing regulations and approved procedures.

3. The weight and centre of gravity were within the prescribed limits.

4. The number 1 engine clutch coupling shaft sheared because of the excessive loads placed on it when the worn clutch slipped and then suddenly re-engaged. The power turbine wheel then over sped sufficiently for the turbine blades to fracture, with blades from both power turbine wheels breaking through their respective steel containment rings.

5. The number 2 engine continued to run while the helicopter was on its side, and the engine eventually failed because of a lack of lubrication.

6. No single definitive cause for the significant clutch wear was determined.

Causes and Contributing Factors

The number 1 engine clutch coupling shaft sheared because of excessive loads placed on it by the worn and slipping clutch. The power turbine then oversped, causing the engine to lose power, and forcing the pilot to land at an unprepared landing site.

Safety Action Taken

Since the accident, the operator has introduced a cost-sharing programme with its pilots to assist them with the purchase of their flight helmets.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 25 February 1998.