Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A03P0136

ENGINE POWER LOSS – HARD LANDING AND ROLLOVER

CARIBOO CHILCOTIN HELICOPTERS LTD.
BELL 206B C-GPOS
WARD CREEK, BRITISH COLUMBIA
06 JUNE 2003

Canada

Aviation Occurrence Report

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Summary

The Bell 206 helicopter, serial number 845, registration C–GPOS, with one pilot and two forestry workers aboard, was hovering approximately 150 feet above a forestry cut block, about 4000 feet above sea level. It was about 0600 Pacific daylight time, the sky was clear, the winds were light and variable, and the outside air temperature was about 14°C. The crew were scanning for hot spots in the cut block when black smoke engulfed the cabin. The pilot turned the helicopter to the right, lowered the collective, and descended in an attempt to reach a road.

As he applied collective in a high flare to reduce the helicopter's rate of descent, the pilot sensed a deterioration of power by way of diminishing rotor rpm. He immediately "bottomed" the collective then raised it in the final stages of the emergency landing. The helicopter landed hard, nose down, short of the road, and the skid landing gear collapsed. The helicopter turned about 180 degrees and rolled onto its left side. The engine continued to run and was shut down by the pilot. The smoke was not apparent after the emergency landing and there was no post-impact fire. The pilot and the front seat passenger were trapped in the wreckage for a short time until the back seat passenger was able to assist them. The pilot suffered a back injury and both passengers suffered minor injuries. The helicopter was substantially damaged.

Ce rapport est également disponible en français.

Other Factual Information

The wreckage was transported to the Transportation Safety Board of Canada (TSB) facility in Richmond, British Columbia, for examination. External inspection of the engine revealed no anomalies, and both the compressor and power turbine wheels rotated freely. The engine to main rotor transmission coupling was found separated and its grease had flung out, and one of the coupling boots was burnt. Close examination of the coupling indicated that it had been compressed and pulled apart. The main-rotor transmission area revealed damage consistent with the main-rotor transmission rocking fore and aft before deforming its mounting and coming to rest in a forward tilt of approximately 20 degrees. The fuel cell was intact and contained about 500 pounds of fuel. The fuel valve was selected off, and the throttle was in the closed position.

The landing gear skid tubes and forward cross tube were broken and the cross tubes had rotated aft and up. There were marks where the after-market step attached to the cross tubes had come up against the pilot's door, preventing it from opening. Bell 206 series helicopters are not normally equipped with doors or windows that have emergency release systems, and this helicopter had none. The bottom of the pilot's seat was deformed slightly, but not enough to allow contact with the seat support honeycomb plate.

During the examination of the engine, it was installed in an approved engine test facility where a full test was attempted; however, the engine vibrated excessively and the test was aborted. Some smoke was evident during the spool down of the engine. The engine was then disassembled for inspection. Of the 38 blades on the number 1 gas producer (GP) turbine, 29 were damaged significantly. One was broken off close to its root, and most of the others were missing pieces. Examination of the remaining fracture surface of the blade that broke close to its root showed indications of a progressive failure (fatigue crack). The other fracture surfaces showed failure by overload. More detailed examination of the GP turbine blades showed extensive sulfidation corrosion[1] (see Photo 1). The blade surfaces were flaking and there were fatigue cracks in many of the blades. The turbine first-stage nozzle labyrinth seal was damaged and the outer fibreglass packing was partially missing. There was soot at the joint between the turbine nozzle and number 1 GP turbine and thick, black, wet soot around the labyrinth seal and on the turbine coupling.

Photo 1. Sulfidation of number 1 GP turbine

On 10 February 2000, Rolls-Royce Allison issued a Commercial Service Letter, *Hot Corrosion-Sulfidation,* describing hot corrosion (sulfidation) and suggesting that operators look for it. However, no periodic maintenance inspection was directed by Transport Canada (TC) and none was implemented by the operator with regard to sulfidation corrosion.

Engine compressor washing is recommended in corrosive and dirty environments. It is also prescribed when engine performance has depreciated, as noted from power assurance checks. However, there has been concern that some tap water can in itself be corrosive. Operators rarely do compressor washes when their helicopters are operating away from a salt environment. They will wash compressors when they can see dirt building up at the air intake, or when an engine is performing below specifications. It is not clear if compressor washing effectively cleans the GP turbine wheel.

1 Sulfidation corrosion is hot corrosion of airfoil material aggravated by a deposition of contaminants, particularly sea salts.

A review of the helicopter's log books and maintenance documentation revealed that the helicopter was maintained in accordance with the standards approved by TC, and that there was no requirement for the company to comply with the manufacturer's recommendations regarding maintenance. The GP turbine had reached 1374.4 hours since new, which is 400.6 hours before reaching its time for replacement. Documented engine power assurance checks, after the turbine was installed, show the engine to be performing above specifications. However, there were no power assurance checks documented just before the accident, and there were no compressor washes documented, nor were either required by regulation. During the time this turbine was installed, this helicopter operated primarily in what is perceived to be a non-corrosive environment (dry, sparsely populated, inland, etc.) However, sulfidation can be triggered by corrosive substances found in most environments, such as smoke. The number 1 GP turbine wheel had been installed with about 200 hours of previous use in an unknown environment.

Operating a single-engine helicopter at 150 feet above ground at a slow airspeed or hovering compromises the pilot's ability to complete an emergency landing successfully in the event of an engine power loss. The helicopter flight manual includes a height /velocity chart that documents this risk. The risk is enhanced by increased helicopter gross weight and high density altitude. At the time of the accident, the helicopter was being operated at a density altitude of approximately 4500 feet and at a gross weight of approximately 3000 pounds, within the limitations set out by the manufacturer. The maximum gross weight of the helicopter is 3200 pounds.

The pilot's experience on the helicopter type was extensive. His training and certifications were current and appropriate for the operation.

Analysis

The investigation first focussed on the failure of the input drive coupling between the engine and the main-rotor transmission. Close examination of the coupling indicated that it had been compressed and pulled apart. The extent of transmission and/or engine movement to facilitate this disconnect was not possible under any flight conditions. Furthermore, damage from the hard landing showed that the main rotor transmission rocked fore and aft, deformed its mounts, and allowed the transmission to tilt forward enough to pull the coupling apart. It was, therefore, concluded that all of the damage to the helicopter, excluding the engine, was the result of the hard landing and rollover. The following analysis focuses on the engine.

The vibrations experienced when the engine was run in the test facility were extreme enough that they would have been detected by the pilot had they been present before the occurrence. Also, because the engine did not appear to suffer any damage from the hard landing, it was concluded that the imbalance occurred at about the time the smoke came into the cabin. This imbalance was determined to have been caused by the separation of parts of the GP turbine blades.

There were no periodic power checks carried out, or required, by the operator to detect a power loss, nor maintenance inspections required by the manufacturer or the operator for sulfidation corrosion. It is suggested that either power checks or maintenance inspections would have led to the discovery of the corroded turbine components. The identified sulfidation weakened the GP turbine blades, fatigue cracks occurred on many of the blades, and one of the blades separated. Parts of other GP turbine blades broke off and engine power was lost.

The loss of the blade and other blade sections caused an imbalance, which then likely resulted in damage to the turbine seals. It is likely that the seal damage allowed the release of oil onto hot engine areas, resulting in the soot in the turbine at the joint between the turbine nozzle and the number 1 GP turbine and the smoke in the cabin. Another scenario is that the smoke came from the burnt boot for the input drive coupling. This scenario, however, is not supported by the information gathered during the investigation, which clearly indicates that the coupling failed during the hard landing.

The pilot reacted immediately to the smoke by lowering the collective. The helicopter was operating in a hover, about 150 feet above the ground at a relatively high density altitude, and at a weight near the maximum allowable. Regardless of the reason for the smoke or when power was lost, a successful landing with reduced power was unlikely. As the pilot tried to arrest the helicopter's descent, rotor rpm decayed, and not enough thrust was available to cushion the landing.

When the landing gear skid tubes and forward cross tube broke, the cross tubes rotated aft and up. The after-market step that was attached to the cross tubes came up against the pilot door and the rotated cross tubes caused the step to be jammed against the door, preventing it from opening normally, and there was no emergency release system for the doors or windows. Because the helicopter was on its side, the other door was not usable, and the pilot and front passenger were trapped inside the helicopter.

The following TSB Engineering Laboratory report was completed:

LP 037/04 – Gas Producer Wheel, Bell Helicopter 206B, C–GPOS

This report is available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. Periodic power checks or inspections for sulfidation corrosion, which most likely would also have detected a power loss and the corroded turbine components, were not undertaken, nor were they required.

2. A blade in the number 1 GP turbine failed as a result of fatigue, which resulted from sulfidation corrosion; the engine lost power as a result of the blade failure.

3. The helicopter was operating in a high hover when the engine lost power. The ensuing forced landing was hard, the landing gear broke, and the helicopter rolled over.

Findings as to Risk

1. The after-market step that was attached to the landing gear cross tubes blocked the pilot's door and trapped the pilot and passenger in the wreckage.

2. Bell 206 series helicopters are not normally equipped with doors or windows that have emergency release systems.

Safety Action Taken

On 18 July 2003, the TSB sent a Safety Information Letter to TC, with copies to Bell Helicopter Textron; Aeronautical Accessories, Inc.; British Columbia Forest Service; and Cariboo Chilcotin Helicopters Ltd. The letter described the conditions that resulted in the pilot's door being blocked by the after-market step. This information was provided to TC, to take whatever action it deemed necessary.

On 03 October 2003, the TSB sent a Safety Advisory (A030018) to TC, with copies to Rolls-Royce, Bell Helicopter Textron, and Cariboo Chilcotin Helicopters Ltd., drawing attention to the predominant cause for the engine power loss – sulfidation corrosion. Because periodic inspections are not required, the risk of this corrosion going undetected in other aircraft powered by Rolls-Royce 250 engines remains. The letter stated that TC may wish to consider whether periodic inspections should be carried out to help detect damage caused by sulfidation corrosion.

TC responded to the Safety Advisory on 05 February 2004, suggesting that in the absence of data substantiating the need for scheduled washings of the compressor (and turbine) blades, the introduction of such a schedule is deemed unnecessary. The response also stated that although there was evidence of sulfidation found on the failed turbine, it is not linked directly to the cause of failure of the blades. In the absence of such a link, TC deemed it appropriate to continue to rely on visual inspection and performance runs as the means for limiting the effects of turbine blade sulfidation.

Subsequent to TC's first response, the TSB Engineering Branch conducted a further examination and testing, and documented its findings in report LP 037/04. On reading that report, TC provided a second response, dated 15 April 2004, in which it concluded that sulfidation was indeed the process by which the turbine blades deteriorated and eventually failed due to fatigue. TC will recommend to the engine manufacturer that an inspection for sulfidation on the turbine blades of this engine be implemented, and that this recommendation will be tracked in TC's Civil Aviation database.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 21 July 2004.