AVIATION INVESTIGATION REPORT
A01P0100

IN-FLIGHT BREAK-UP

BC HELICOPTERS
ROBINSON R22B HELICOPTER C-FHRL
ABBOTSFORD, BRITISH COLUMBIA, 10 NM E
16 MAY 2001

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Summary

The Robinson R22B helicopter, C-FHRL, serial number 1361, was operating with a flying instructor and a student on board. About 10 nautical miles east of the Abbotsford airport, the helicopter was seen to break apart in flight and fall to the ground. No one observed the helicopter before the accident sequence began; however, several persons saw it descend in a flat attitude and pieces fall from it. They also observed that the main rotor was stationary and that the blades were coned. A mist with a strong smell of fuel was reported by the first person to arrive at the scene. No fire occurred. Both occupants were fatally injured.

Ce rapport est également disponible en français.

Other Factual Information

The instructor was conducting his first instructional flight with a student since qualifying for a Class 4 helicopter instructor rating. He held a commercial helicopter pilot licence and a type rating for the Robinson R22. He had flown about 2900 hours on helicopters, of which approximately 1600 hours were on the Robinson R22 and R44. His last medical, which included an electrocardiogram, was conducted on 18 April 2001 and was assessed as Category 1 with no limitations.

The student was receiving his initial familiarization flight as a student helicopter pilot. His medical examination was conducted on 25 April 2001, and he was assessed as Category 1, with the limitation that glasses must be worn.

Autopsies of the instructor and the student, including a full toxicology screening, did not reveal any conditions that could have led or contributed to the accident.

At the time of the accident, the weather conditions were suitable for flight in accordance with visual flight rules. The actual weather at the Abbotsford airport, 10 nautical miles west-southwest of the accident site, at 1400 Pacific daylight time,[1] 37 minutes before the accident, was as follows: wind 240° true at 12 knots gusting to 18 knots; visibility 25 statute miles; a few clouds at 2500 feet, broken clouds at 4500 feet, and broken clouds at 21 000 feet; temperature 14°C; and dew point 5°C. Weather data recorded at an agricultural locale bordering the accident site showed the wind speed to be 6 knots gusting to 14 knots at the approximate time of the accident. The wind direction was not recorded. According to the carburettor icing chart in *Aeronautical Information Publication*, section AIR 2.3, a temperature of 14°C and a dew point of 5°C falls right at the boundary between “serious icing at any power” and “moderate icing at cruise power or serious icing at descent power”. The carburettor heat control was found in the OFF position.

Logbooks and maintenance records indicate that the Robinson R22B had been certified, equipped, and maintained in accordance with existing regulations and approved procedures. It was reported that, on departure from Abbotsford, the helicopter had 50 litres of fuel on board, which would give an endurance of about two hours. The accident occurred about 20 minutes after the helicopter took off. The helicopter had no known deficiencies before the flight and was operating within its load and centre-of-gravity limits.

The wreckage was initially examined at the accident site. The helicopter struck the ground in a slightly right-banked, flat attitude. The debris field indicates that the helicopter was either stopped or proceeding very slowly in a north-northeasterly direction. The main-rotor blades were found bent into a tulip shape. This indicates low rotor-rpm during the descent to the ground.

The wreckage was recovered from the accident site for a more detailed examination at the TSB regional wreckage examination facility. Paint transfer marks indicate that the main-rotor blades contacted the fuselage at the strobe light mount area and chopped off the tail boom. This is supported by the deformation of both main-rotor blade spindle tusks, indicating excessive blade flap downward. The breaks on the tail-rotor drive shaft exhibited signature blade strikes to the tail boom at low rpm.

The main-rotor hub assembly showed some indications of mast bumping. The mast was bent immediately below the hub, but these indications were not severe. (In most instances of high-energy rotor/fuselage contact,

[1] All times are Pacific daylight time (Coordinated Universal Time minus seven hours).

the indications are severe.) Both teeter and droop stops were found in place. The main-rotor hub displayed "smile" marks on both sides from contact with the main-rotor pitch horn circumferences. These marks are consistent with both blades being coned upwards.

A teardown and an inspection of the Lycoming engine (model O-320-B2C, serial number L-7020-39A) was conducted at a Lycoming overhaul facility in Richmond, British Columbia, on 29 May 2001. Engine damage noted during this teardown was consistent with the engine contacting the ground and the airframe during the accident. The engine appeared to be mechanically capable of producing power before the accident, although it was not operating at impact. No indication was found of pre-existing damage or defects that could have contributed to the accident circumstances.

The engine was fitted with an electronic fuel control governor to help the pilot maintain rotor rpm and reduce the risk of low rotor-rpm leading to rotor stall. This installation featured a governor on/off switch on the end of the student pilot's collective lever. This collective governor switch was destroyed in the crash. All governor components, both magnetos, and the governor off and low-rpm warning light bulbs were sent to the TSB Engineering Laboratory for analysis. It was not determined whether the governor was operating when the accident sequence began, but information from laboratory analysis suggests that the governor was off at impact.

With two persons on board and full fuel, the R22 is operating at close to its maximum gross weight of 1370 pounds. This results in operations being routinely conducted near the upper limit of this helicopter's operating envelope, which, in turn, is near the maximum design lift capability of the main-rotor system. To gain the needed lift, the R22's main-rotor blade angle of attack will on occasions be near the stall angle of attack during normal operations. A simulation study conducted by the Georgia Institute of Technology revealed that large, abrupt control movements may cause a rapid decay of the rotor rpm due to the low inertia of the main rotor. The most effective technique to recover from low rotor-rpm is to immediately lower the collective to decrease the blades' angle of attack, flare to transfer airspeed energy to rotor energy, and roll on throttle.

In this accident, mast bumping marks and other damage to the main-rotor hub assembly are consistent with a low-energy situation, which would correspond to a low-rotor-rpm stall.

Rotor stall due to low rpm has resulted in many helicopter accidents. At the stalling angle, usually around 15°, the airflow over the rotor blades will abruptly separate, causing a sudden loss of lift and a large increase in drag. A rotor stall occurs because of low rotor-rpm. As the rotor rpm decreases, the angle of attack of the rotor blades must be increased to generate the lift required to support the helicopter, else the helicopter will descend. Once the rotor blades reach the stalling angle of attack, lift suddenly decreases and drag greatly increases. This increased drag acts like a huge rotor brake, causing the rotor rpm to decrease further, accentuating the effect of the rotor stall. Once the rotor rpm has decayed significantly, recovery is unlikely because, as the helicopter begins to descend, the upward rushing air further increases the angle of attack of the slowly rotating blades. A tail boom chop often accompanies a low-rotor-rpm stall because of asymmetrical rotor stall, that is, the tendency for the helicopter to pitch nose-down due to the upward airflow under the tail surfaces and the application of aft cyclic by the pilot in an attempt to keep the nose from dropping.

A search of the TSB database has revealed that in Canada since 1993 there have been nine similar R22 helicopter occurrences in which rotor rpm was allowed to decay. A search of the US National Transportation Safety Board database revealed 27 similar occurrences in the US since 1983.

Analysis

Nothing was found to indicate that any mechanical malfunction initiated or contributed to the accident sequence, and there was usable fuel on board; therefore, this analysis focuses on the operational aspects of the flight. Weather is not considered to have been a factor in this accident, except that the conditions were conducive to carburettor icing.

Information gathered from the accident site and the examination of helicopter wreckage clearly indicate that the helicopter rotor-rpm decreased, likely to a stop, before the helicopter struck the ground. It is not clear what event or manoeuvre precipitated this condition of low rotor-rpm. However, the wreckage and site signatures, light bulb analysis, and the position of the carburettor heat control (cold) suggests two plausible scenarios that could have led to the final circumstances of this accident:

> The first scenario is the demonstration of a helicopter descent without power, intending to make a power-on recovery at a comfortable height above the ground, as follows:
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> - The instructor slows the helicopter and lowers the collective pitch control to the bottom of its travel.
> - He closes the throttle to idle, thus demonstrating that the engine is no longer driving the rotor.
> - To recover, he opens the throttle to match the engine rpm to the rotor rpm and raises the collective to arrest the rate of descent.
> - The rotor rpm decreases for one of two reasons:
>   1) The instructor increases collective pitch before the engine throttle is open enough to power the rotor.
>   2) Carburettor ice had formed during the power-off descent, and when the instructor increased collective pitch, the engine could not deliver enough power to drive the rotor.
>
> The second scenario is as follows. The R22 helicopter has a record of accidents during flights with students having less than four hours' dual flight instruction, especially on initiation flights. While manipulating the flight controls, the student might have made a large, abrupt collective control input causing the rotor rpm to decay, and the instructor was not able to recover control of the helicopter. This scenario would be consistent with the carburettor heat being found in the OFF position and the information that the helicopter was moving very slowly just before the accident. Since rotor divergence and high-energy rotor/fuselage contact is not consistent with the known facts, mishandling of the cyclic control is not likely part of this scenario.

Why the instructor did not immediately recover the rotor rpm when it began to decrease is not clear. The Robinson R22B is susceptible to rapid loss of rotor rpm if mishandled. Quick recovery action is required by the pilot. Considerable airspeed, which can be traded for energy to the rotor system, is also necessary. If rotor rpm significantly decreases at a slow airspeed, rotor stall may be inevitable.

Findings as to Causes and Contributing Factors

1. Rotor rpm decayed, for reasons that could not be determined, causing the main-rotor blades to sever the tail boom and, ultimately, to stall.

Findings as to Risk

1. The Robinson R22B helicopter's low-inertia rotor design is susceptible to rapid loss of rotor rpm if mishandled. If rotor rpm significantly decreases at a slow airspeed, rotor stall may be inevitable.

2. The carburettor heat was OFF, which increased the likelihood that carburettor ice adversely affected engine performance.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 15 May 2002.