Log 2328

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 13, 1992
In reply refer to: A-92-81 through -83

Honorable Thomas C. Richards
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On September 27, 1991, a Mitsubishi MU-2B-60, Canadian registry C-FFSS, on a cargo flight, sustained substantial damage when a propeller blade separated in flight near Utica, New York. The airplane was climbing through 19,000 feet when the pilot felt a strong vibration, followed shortly by a loud "bang." The vibration increased and became so severe that the pilots experienced considerable difficulty controlling the airplane. Despite this difficulty, the airplane was successfully landed at the Utica airport, with no injuries.

Postaccident examination of the airplane revealed that one of the four arms of the propeller hub for the No. 2 engine had separated, releasing one of the four propeller blades in flight. The released blade hit and damaged an adjacent blade on the same engine and ripped a 12-inch hole in the pressurized portion of the fuselage. The severe vibration resulting from loss of the blade caused substantial twisting and wrinkling of the wings and a partial separation of the No. 2 engine nacelle from the engine truss mounts. The released blade and associated blade clamp, pilot tube, and separated portion of the hub have not been recovered.

Metallurgical examination of the broken Hartzell propeller hub, model HC-B4TN-5DL, was conducted at the Safety Board's materials laboratory. The hub arm fracture was located about 2.3 inches inboard of the outboard end of the hub arm. The fracture was caused by a fatigue crack that initiated from multiple sites on the inside diameter surface of the arm and progressed through 70 percent of the arm cross section before final separation. The fatigue crack initiation area was approximately in line with the inboard end of the pilot tube that is assembled into the hub arm bore with an interference fit. During operation of the propeller, a slight stress increase is expected to occur at the position corresponding to the assembled inboard end of the pilot tube, and this may have caused the fatigue origin area to be located at this radial position.

The inside diameter surface of the separated hub arm contained scratch marks that extended over about one-half of the hole wall circumference and from the fracture surface to a position slightly inboard of the plane of the fracture. The fatigue origin area was located within this area of scratches.

Examination of the three remaining intact arms after removal of the pilot tubes disclosed evidence of scratch marks similar to those found on the separated arm.

As the propeller rotates, the predominant load experienced by the hub arm is from the centrifugal loads on the propeller blades. These loads result in radial tension throughout the hub arm. In addition, drag and thrust loads on the blades produce bending in the hub arms. During normal operation (in forward propeller thrust), these bending loads result in maximum tension in the aft leading-edge quadrant of the hub arm. During reverse thrust, the maximum tension would be in the forward leading-edge quadrant of the hub arm. However, the fatigue origin area was not located in either of these quadrants, but was, instead, found in the forward trailing-edge quadrant of the hub arm, suggesting that the circumferential location of the fatigue initiation region was not influenced by bending loads but may have been determined by local stress raisers such as the scratches on the inside diameter surface of the separated hub arm.

The separated propeller hub was manufactured in 1977 and was overhauled in 1983 and 1988. Records from the first overhaul are not available. The records from the second overhaul indicate that two of the four pilot tubes had been replaced at that time. Because similar scratches were found on all four hub arms, it is unlikely that the scratches were introduced during the more recent overhaul. Also, the scratches extended inboard of the position contacted by the pilot tubes, and it is unlikely that removal or insertion of the tubes could create such damage. However, the scratches could have been created by some manufacturing or repair process any time that the pilot tubes were not present in the hub arms. The Safety Board believes it more likely that scratches were produced during original manufacturing of the hub.

General corrosion damage and corrosion pitting were also noted on various portions of the inside diameter surface of the remaining portion of the separated hub arm, including the area from which the fatigue cracking initiated. The general corrosion damage had partially obliterated the scratches from the inside diameter surface. Scanning electron microscopic examination of the fracture revealed no evidence of corrosion pits at the individual fatigue initiation sites, indicating that corrosion may not have substantially contributed to initiation of the fatigue cracking.

The Safety Board believes that it is more likely that the fatigue cracking on the separated hub initiated from the scratches than from corrosion damage. Regardless of the cause of initiation, the failure of a hub arm on a HC-B4 propeller hub could result in a catastrophic accident.

The separated hub, model HC-B4TN-5DL, had accumulated a total of 4,432 hours of operation since new. Information provided by Hartzell indicated that the highest time model HC-B4 propeller hub (manufactured since the 1960s) has accumulated about 15,000 hours of operation. The Safety Board believes that all HC-B4 Hartzell propeller hubs that have accumulated at least 3,000 hours should be subjected to a one-time inspection for cracks.

Hartzell recommends that the HC-B4 propeller be overhauled every 5 years or 3,000 hours, whichever comes first. Performing the hub inspection at the next recommended overhaul could allow passage of too much time before the inspection is performed. Therefore, the Safety Board believes that the hubs should be inspected the next time that the propeller assembly is overhauled, or at the next annual inspection (or equivalent), whichever occurs first. If the inspection of these hubs reveals additional hubs with cracks, then periodic inspections of the HC-B4 hubs may also be necessary.

The interference fit between the pilot tube and the hub arm increases the possibility that removal and reassembly of the pilot tubes (to do a direct inspection of the inside diameter surface of the hub arms) could damage the hole wall. However, the Safety Board believes that hub arm cracks could be detected without removal of the pilot tubes through the use of an inspection method such as ultrasonic inspection.

The design of the HC-B4 hub and the manufacturing processes used to make it are very similar to the design and processes used to make the Hartzell three-bladed hub (basic model HC-B3) and the Hartzell five-bladed hub (HC-B5). Hartzell has made more than 27,000 three-bladed hubs and more than 1,300 five-bladed hubs. Because of the similarities between the types of hubs, the Safety Board is concerned that hubs of the three- and five-bladed design could also be susceptible to cracking because they could have damage similar to the scratch marks and corrosion found on the separated four-bladed hub. A failure of a hub arm on a three- or five-bladed hub could also result in a catastrophic accident, and the Safety Board believes that inspections of these hubs may also be necessary to determine if they have a cracking problem.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Develop, with the assistance of Hartzell Propeller, Incorporated, a nondestructive inspection technique capable of detecting hub arm cracks stemming from the inside diameter surface of the hub arm at the approximate location of the inserted end of the pilot tubes on Hartzell model HC-B4 propeller hubs, and issue an airworthiness directive requiring that HC-B4 hubs with 3,000 hours or more be inspected using this technique the next time the propeller assembly is overhauled for any reason, or at the next annual inspection (or equivalent), whichever is first. (Class II, Priority Action) (A-92-81)

> Determine, based on the results of the inspections requested in Safety Recommendation A-92-81, if the hub arms on Hartzell model HC-B4 propeller hubs with 3,000 hours or more should be inspected at periodic intervals. If such inspections are warranted, issue an airworthiness directive, as appropriate, requiring periodic inspections. (Class II, Priority Action) (A-92-82)

Determine if Hartzell model HC-B3 and -B5 propeller hubs, based on similarity of design and fabrication processes with the HC-B4 propeller hub, should be inspected for cracking in the hub arms. If such inspections are warranted, issue an airworthiness directive, as appropriate, requiring periodic inspections. (Class II, Priority Action) (A-92-83)

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HART, and HAMMERSCHMIDT concurred in these recommendations.

By: Carl W. Vogt
Chairman