AVIATION INVESTIGATION REPORT
A03C0118

ENGINE FAILURE – FORCED LANDING

WHITESHELL AIR SERVICE LTD.
de HAVILLAND DHC-3 OTTER C-GGON
LAC DU BONNET, MANITOBA 2 NM E
22 MAY 2003

Aviation Investigation Report

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Summary

The Whiteshell Air Service Ltd. float-equipped de Havilland DHC-3 Otter, C-GGON, serial number 225, with one pilot and three passengers on board, departed the Lac du Bonnet, Manitoba, water base at approximately 1100 central daylight time on a day, visual flight rules flight to George Lake. The pilot completed a normal take-off from the Winnipeg River in an easterly direction and began a shallow climb over the shoreline. As the aircraft levelled at approximately 400 feet above ground level (agl), there was a loud backfire followed by a complete loss of engine power. The pilot force landed straight ahead; the aircraft struck several large trees and came to rest in a swampy area. The aircraft struck the ground on its left side, both wings broke off, and the engine was buried in the swampy ground. There was no fire.

The pilot and one of the passengers were seated in the cockpit and suffered minor injuries. One of the passengers seated in the cabin of the aircraft was thrown clear of the aircraft still strapped in the seat and sustained minor injuries. The other cabin passenger was thrown forward still strapped in the seat, struck the interior structure of the aircraft, and sustained serious injuries.

Ce rapport est également disponible en français.

Other Factual Information

On the day before the accident, the aircraft had returned to Lac du Bonnet, Manitoba, with an unusual engine noise. The engine was inspected by the operator's own approved maintenance organization (AMO), and the No. 1 cylinder showed signs of excessive blow-by. The cylinder was removed and inspected. The cylinder head was found to be separating from the cylinder barrel. A new cylinder was installed. On the day of the accident, prior to the first flight following the cylinder replacement, a lengthy engine run-up was completed with no anomalies noted. At take-off, the pilot determined that the engine was performing satisfactorily by confirming that the engine's rpm was 2250 at a manifold pressure of 36.5 inches.

The power output of this type of aircraft engine is checked by measuring the engine rpm at a given manifold pressure. The field barometric pressure is used to establish the manifold pressure. This check requires that the engine rpm be measured at this pressure when the propeller blades are at their low pitch stops. The aircraft manufacturer specifies the rpm at which this occurs. The approved aircraft flight manual for C-GGON indicates that the engine's rpm should range from 2000 to 2200 rpm when the manifold pressure is equal to the field barometric pressure.

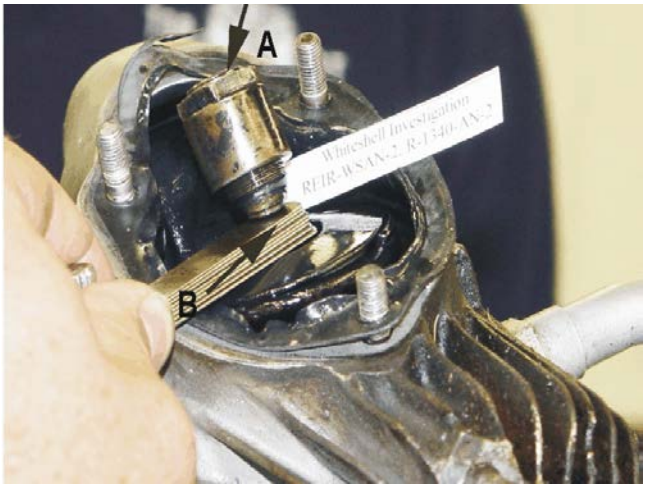
The weather at the time of the accident was reported as visual meteorological conditions (VMC) with light winds from the east. The weather at Kenora, Ontario, approximately 75 statute miles east, was representative of the area weather and was reported as follows: visibility greater than 15 miles; a few clouds at 3700 feet agl; temperature 15°C; dewpoint 6°C; wind 150 degrees true at 7 knots.

The pilot, who was also the owner of the company, held a valid commercial pilot licence. The pilot had extensive flying experience with over 32 000 flying hours, over 8000 hours on type, and 2.7 hours in the last 30 days. The pilot was also the sole aircraft maintenance engineer (AME) for the company's AMO. The pilot's AME licence had expired in 05 October 2000 and had not been renewed. The last aircraft inspection was completed by the pilot/AME, after the expiry date of his licence.

After the accident, no emergency locator transmitter (ELT) signal was received from the downed aircraft. The ELT had been removed by a company apprentice for re-certification on 08 May 2003 during an annual inspection of the aircraft. An entry was made in the journey log book stating that the ELT had been removed. Information provided, however, indicated that the pilot of the aircraft was under the impression that a re-certified ELT had been installed in the aircraft in the interim.

The *Canadian Aviation Regulations* (CARs) allow an aircraft to be operated without a serviceable ELT for a period of up to 30 days, providing certain conditions are met. One condition is that the operator display a placard in the cockpit noting the removal. Although there was an entry in the log book stating that the ELT had been removed from the aircraft, the aircraft was not placarded to indicate that the aircraft was operating without an ELT.

An examination of the airframe did not reveal any pre-impact anomalies. The engine, a Pratt & Whitney Wasp R-1340-S3H1-G, was removed from the accident site and taken to a local overhaul facility for tear-down analysis. During the rotation of the crankshaft, it was noted that the No. 3 cylinder exhaust valve did not open. The valve adjustment screw assembly was observed to protrude above the lock nut by 1/16 of an inch and the valve clearance was measured at 0.233 of an inch. The engine's maintenance manual specifies a minimum protrusion of the valve adjustment screw of 1/8 of an inch and a valve clearance of 0.035 of an inch (Figure 1).



The front engine case was removed and the No. 3 cylinder exhaust roller was found to be excessively worn. The top portion of the cam roller slot tappet guide had split off and broken. The cam roller was measured and found to be worn 0.249 of an inch with a flat spot on one side (Appendix A). The cam ring was inspected and all four exhaust lobes were found to be excessively worn and out of limits. The No. 3 cylinder exhaust valve push rod was inspected and the ball ends were removed to check for the number of adjustment spacers under the ends. Push rods can be lengthened or shortened by adding spacers underneath the ball ends to accommodate valve adjustments during overhaul or cylinder replacement. Two spacers were noted under one end with one spacer found on the opposite end. The single spacer, however, had been installed standing on end and had been forcibly folded over at a right angle.

A review of the aircraft maintenance records indicated that the engine had accumulated a total of 821.1 hours since the last major overhaul by Covington Aircraft Engines Inc. Reportedly, the valve clearances had been checked and adjusted twice since overhaul, once at 100 hours and again at 810.7 hours time in service (10.4 hours prior to the accident). During both adjustments, no significant anomalies were noted; however, it was not determined whether the No. 3 exhaust valve had been adjusted. Reportedly, the push rods had not been lengthened or shortened to achieve the required valve clearances. Aircraft maintenance records indicate that the No. 3 cylinder had not been replaced since overhaul. The valves were adjusted using the "Positive Method," as specified in the engine's maintenance manual, to eliminate cam float during the adjustment procedure. The operator's inspection program specifies that the valve clearances are to be checked at 400-hour intervals. It could not be determined when the No. 3 exhaust valve was last adjusted or when the valve adjustment screw protrusion was set beyond limits.

Both cabin passengers were seated in the rearmost row of seats. The seats in the two rows immediately ahead of them had been folded up because they were not in use. The seat structures of both passengers failed. The passenger in the left seat was thrown clear of the aircraft still strapped in his seat through the side door and received only minor injuries. The seriously injured passenger was seated in the right seat. This passenger, still strapped in the seat, was thrown forward violently and seriously injured when he came in contact with the folded seats and other parts of the aircraft's structure. Inspection of the cabin revealed that the seats were all factory-approved installations and were correctly installed. Examination of the crash site revealed that the aircraft experienced high deceleration forces during the crash sequence.

Analysis

The failure of the No. 3 cylinder exhaust valve to fully open was progressive as the cam roller wore. Because the required field barometric power reference check was not completed after the replacement of the No. 1 cylinder or prior to take-off, the operator did not ascertain whether the engine was operating correctly at higher power settings. Consequently, the effects of the closed or near closed exhaust valve went undetected and may have been masked by the failure of the No. 1 cylinder.

During assembly of the No. 3 cylinder exhaust push rod, a spacer was incorrectly installed end-wise under the ball end. When the ball end was pressed into place, the spacer was likely set and partially bent within the tube, bringing the overall length of the push rod into a range that was considered satisfactory during installation. The investigation was unable to determine when the spacer was incorrectly installed.

During normal engine operation, the repetitive lifting action of the valve would have further bent the spacer, effectively shortening the overall length of the push rod and increasing the clearance between the valve and the valve rocker. This increased clearance would have resulted in a pounding action of the cam roller against the cam ring lobes. An adjustment of the valve clearance during the inspection conducted at 100 hours time in service would likely have brought the clearances back into tolerance; however, the cam roller and cam ring had already been damaged. Small fragments of cam roller material would have begun to break off, creating a flat spot on the roller. As the roller stopped turning and began to slide over the cam lobes, an increased wear pattern developed. At some point, the valve was again adjusted, accounting for the valve screw protrusion being out of limits. The adjustment was likely made in an attempt to bring the ever-diminishing valve clearance back into tolerance. The wear eventually progressed to the point where the exhaust valve was not opening. The failure of the exhaust valve to open would have resulted in the exhaust gases accumulating in the combustion chamber and migrating back through the opening of the intake valve into the induction system. The hot exhaust gases would have ignited the fuel/air mixture in the induction, resulting in a backfire and the loss of engine power.

The breakage or failure of the top portion of the cam roller slot tappet guide likely occurred because the combination of wear on the No. 3 exhaust cam roller and cam lobes resulted in a longer stroke of the tappet assembly and the eventual protrusion of the cam roller pin beyond the tappet guide. This protrusion of the cam roller pin would have resulted in the cam roller pin drifting outward and splitting the top portion of the tappet guide roller slot. It is likely that the failure of the top portion of the tappet guide roller slot was the result of the engine backfire and did not contribute to the loss of engine power.

It could not be determined when the No.3 exhaust valve was last adjusted or when the valve adjustment screw protrusion was set beyond limits. The company did not check the valve clearances on a progressive 400-hour schedule, as required by the maintenance manual and could not account for the valve adjustment screw protrusion being set beyond limits. Had the out-of-limits screw protrusion been noted during the adjustment of the valve or during a regularly scheduled inspection, an examination might have revealed the excessive wear in the valve train and prevented the engine power loss.

High deceleration forces when the aircraft struck the ground and trees likely exceeded the design strength of the cabin passengers' seats, resulting in an overload failure of the support structure of the seats.

Findings as to Causes and Contributing Factors

1. A spacer in the No. 3 cylinder push rod tube was installed incorrectly. This initiated the increased wear that eventually prevented the No. 3 exhaust valve from opening, resulting in hot exhaust gases migrating into the induction system and causing the engine failure.

2. Following replacement of the No. 1 cylinder, the operator did not complete a field barometric power reference check, which is used in early identification of an engine problem.

3. The valve adjustment screw protrusion was set beyond specified limits. Had the out-of-limits screw protrusion been noted during adjustment or during a scheduled inspection, an examination might have revealed the excessive wear in the valve train and prevented the engine failure.

Findings as to Risk

1. The licence of the AME who signed the aircraft journey log entries had expired.

Other Findings

1. The removal of the ELT was not placarded as required by CARs; the pilot was not aware that the ELT was not installed.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 23 February 2004.

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Appendix A – Worn Cam Roller