# AVIATION INVESTIGATION REPORT
# A00O0214

## ENGINE FAILURE—FORCED LANDING

## OTTAWA AVIATION SERVICES
## DIAMOND DA 20-A1 C-GOAS
## OTTAWA, ONTARIO
## 03 OCTOBER 2000

# Aviation Investigation Report

# Engine Failure—Forced Landing

Ottawa Aviation Services
Diamond DA 20-A1 C-GOAS
Ottawa, Ontario
03 October 2000

Report Number A00O0214

## *Summary*

The student pilot and the flight instructor took off from Ottawa / Macdonald-Cartier International Airport, Ontario, in C-GOAS, a Diamond Aircraft Industries DA 20-A1 aircraft. As the aircraft climbed through 1600 feet above sea level en route to the practice area, the instructor noted the oil temperature was high, and there was smoke in the cockpit. Simultaneously, the engine sputtered and quit. The instructor took control of the aircraft, contacted air traffic control, and declared an emergency. She advised the controller of the smoke and the engine failure and that she would carry out a forced landing in a field south of Highway 417, near Moodie Drive, in Ottawa. The controller called 911 and had police, ambulance, and fire services dispatched. The instructor force-landed the aircraft in a corn field, and both pilots exited uninjured. The aircraft sustained substantial damage to the landing gear and the spar bridge.

*Ce rapport est également disponible en français.*

# *Other Factual Information*

The instructor received flight training on the Katana at Ottawa Aviation Services and had accumulated a total of 467 hours' flight time, of which 113 hours were instructional. She received her Class 4 instructor rating in July 2000. The student pilot started flight training in June 2000. He had accumulated approximately 22 flight hours.

The 1700 eastern daylight time weather report for Ottawa / MacDonald-Cartier International Airport, eight nautical miles east of the accident location, was as follows: wind 300 degrees true at 10 knots gusting to 16 knots; a few clouds at 4000 feet above sea level (asl); scattered cloud at 24 000 feet asl; visibility greater than 15 miles; temperature 19 degrees Celsius; and dew point 10 degrees Celsius.

During the pre-flight walk-around check, approximately 250 millilitres of Motul 10W40 engine oil was added to the engine. No abnormalities were noted by either pilot before take-off.

The engine, a Rotax model 912F3, serial number (S/N) 4412.764, was manufactured by Bombardier-Rotax Gmbh and had accumulated 1235 hours total time since overhaul. This time exceeded the manufacturer's recommended overhaul time of 1200 hours; however, the operator was maintaining the engine to an "on condition" program approved by the regulator.

The engine and the propeller were removed and taken to the TSB Engineering Laboratory for examination. Externally, the engine was generally undamaged, except for a hole in the crankcase. However, the following was observed during the examination:

- The alternator installation bolts were not secured with safety wire.
- The No. 1 ignition cable assembly was loose.
- The sheath on the ground wire for one of the electronic modules was chafed through to the electrical conductor.
- The coolant delivery hose of the No. 2 cylinder was chafed and twisted.
- The crankcase adjacent to the No. 1 cylinder was broken open from the inside.

During disassembly, fretting[1] was found on the mating surfaces of the crankcase. Internally, the crankcase contained a large amount of metallic debris, and there were signs of impact damage throughout the crankcase. Also, lead paste had built up on the various control and compression rings of all the pistons and various other areas and components of the engine. The lead paste seized some of the rings on the various pistons. The No. 1 piston displayed numerous cracks radiating from the oil return holes in the oil control ring groove, and pieces of the piston wall were missing. Two of the exposed fracture surfaces appeared to be polished and shiny. Also, it was noted that the oil return holes were not chamfered.

Engineering Laboratory analysis determined that the piston failed due to long-term progressive fatigue cracking, which initiated from the outside surfaces of the oil holes. This cracking was mostly due to the sharp corners of the holes, which, contrary to normal practice, had not been chamfered. The geometry provided by the sharp corners of the holes increased the stress at those locations, providing ideal sites for crack initiation. The propeller governor body exhibited wear, approximately 0.005 inch in depth, to the outer diameter of the

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[1] *Fretting* is a condition of surface erosion caused by slight movement between two parts that are fastened together with considerable pressure.

propeller governor body adjacent to the return spring and to the inner diameter of the propeller governor return spring.

The propeller reduction gearbox installed on the engine was part number (P/N) 887270 and S/N 13905. It had accumulated 268.9 hours total time since overhaul. After removal from the engine, the manufacturer conducted a check of the gearbox assembly disk spring pre-tension and found the pre-tension to be insufficient. There were too few shims installed between the eccenter collar and the step collar. A bushing, P/N 18983, was seized on the propeller shaft, and circumferential smearing and scoring of this bushing and the bushing case bore were noted. As well, smearing and brinelling[2] were noted on the overload clutch and spring disc washers.

During the disassembly of the propeller gearbox, two gear teeth in drive gear 29T (P/N 834232) were observed to have failed. Visual examination determined the locations of the failed teeth to be diametrically opposed and synchronous with the ends of two ring halves (P/N 926034) installed adjacent to the drive gear. Examination of the ends of the gear teeth adjacent to the half rings, and both sides of the half rings, displayed visible characteristics of fretting and brinelling. Optical examination by the Engineering Laboratory determined the half rings had worn a step into the end of the gear teeth. Beachmarks,[3] an indication of a fatigue fracture, were observed initiating immediately from the wear step.

The propeller was a Hoffman HO-V352F/170FQ, S/N H427. It had accumulated 729 hours total time since overhaul. The propeller was examined and found to be undamaged; however, the propeller had a large amount of balance weight attached to the root of the No. 2 blade and on the engine side of the spinner bulkhead, behind this same blade. The propeller and the spinner were forwarded to the aircraft manufacturer's facilities in London, Ontario, to check the static and dynamic balance of the propeller.

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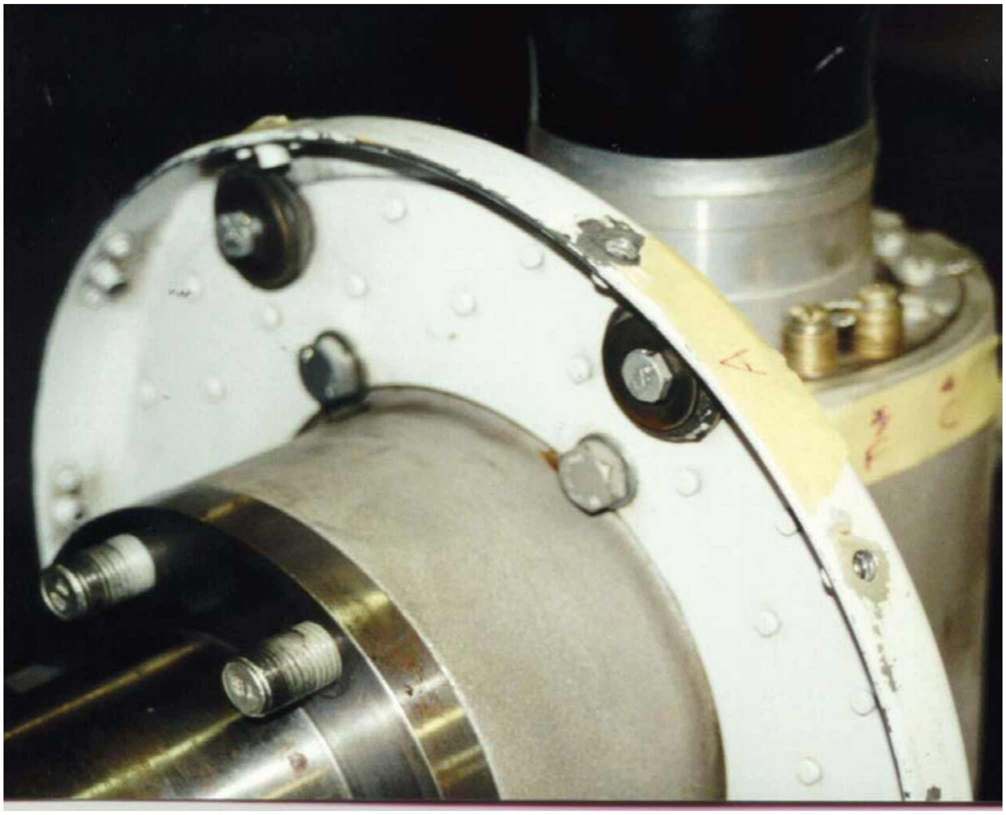
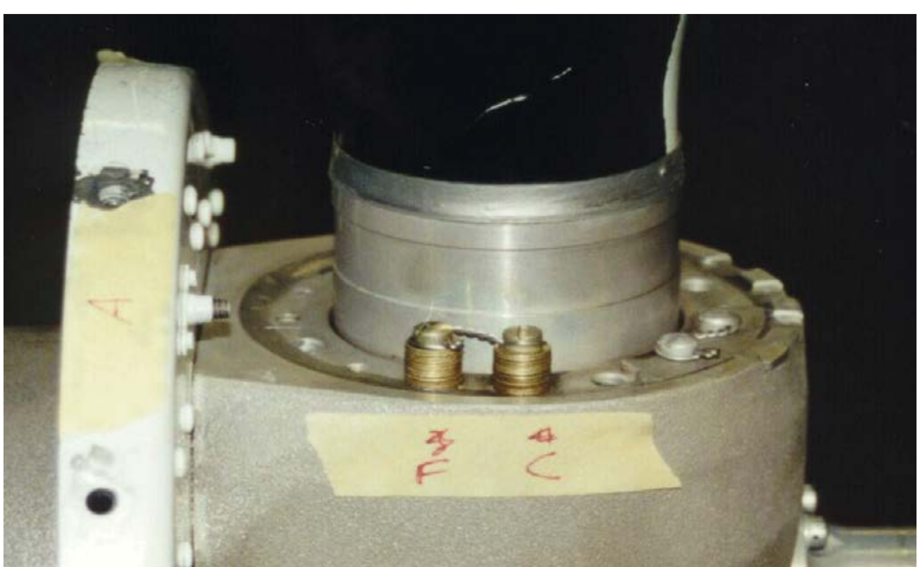
[2] *Brinelling* refers to indentations in bearing races, usually caused by high static loads or application of force during installation or removal. The indentations are usually rounded or spherical, due to the impressions left by contacting balls or the rollers of the bearing.

[3] *Beachmarks* are macroscopic (visible) lines on a fatigue fracture that show the location of the tip of the fatigue crack at some point in time. They are distinct from *striations*, which are extremely small and are formed in a different way.

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The propeller manufacturer's instructions for static and dynamic balancing call for the installation of AN 970-3 balancing shims mounted to the engine side of the spinner bulkhead. The total number of the balancing shims or total weight of the balancing shims in any one position was not to exceed six washers or 28 grams. The occurrence propeller had a combination of AN 970-3 balancing shims and lead washers installed on the spinner bulkhead behind the No. 2 blade (Figure 1). Additionally, there were four stacks of six AN 960-3 washers around the root of the No. 2 blade (Figure 2); this was not in accordance with the manufacturer's instructions.

The total weight of all the balancing weights attached to the No. 2 blade and the corresponding spinner bulkhead positions was 108 grams, whereas the maximum allowable weight was 56 grams. Furthermore, static and dynamic balancing of the propeller showed it to be 33 grams heavy on the No. 2 blade. Additionally, the dynamic balancing of the propeller should not exceed 0.2 inch per second at take-off rpm (revolutions per minute). When checked, the propeller was found to produce a vibration of 0.430 inch per second.

Ottawa Aviation Services contracted the maintenance of its aircraft to an approved maintenance organization (AMO). Several months before the occurrence, Ottawa Aviation Services switched from a local AMO to an AMO in London. If work or servicing was required on an aircraft, the AMO was contacted, and the aircraft was flown to London or an aircraft maintenance engineer (AME) would come to Ottawa from London. The AMO contracted minor repairs and routine servicing, such as 50-hour inspections, to another local AMO or AME.

The last scheduled maintenance on the engine, a 50-hour inspection at 1213 hours total time since overhaul, was completed on 22 September 2000. An oil sample was taken, and a journey logbook entry was made: "Oil sample taken. Traces of metal filings found in oil filter." The sample was forwarded to an oil analysis facility for spectrochemical analysis. The report generated from this analysis, dated 06 October 2000, concluded that the parts per million of iron and aluminum had reached a critical level. The oil analysis history, including samples taken on 22 August 2000 and 26 July 2000, indicated a rise in the parts per million of iron, lead, aluminum, and magnesium. The recommendation generated by the analytical service as a result of the September 22 oil sample stated: "Iron level has increased since last sample. Aluminum level has increased since last sample. Excessive engine wear is possible. Recommend change lube oil and filter. If not already done. Recommend re-sample as soon as possible. Results reported by phone/Fax." When the maintenance facility was contacted on October 10, eight days after the accident, the results of the oil analysis had not been received.

## *Analysis*

The flight crew was certified and qualified for the flight.

Several maintenance discrepancies were revealed during the investigation. Apart from the missing lockwire to secure the alternator mounting bolts, the discrepancies were the result of inadequate clearances, intensified by the vibration produced by the unbalanced propeller.

It is common for an engine to exhibit signs of wear as it ages. However, fretting of the engine crankcase mating surfaces and various other components generally is not observed unless an engine has been subjected to vibration during operation. The logbook entry identifying traces of metal in the filter indicated that an internal problem was developing with the engine. Finding traces of metal in a filter is common and is usually not grounds for immediate removal of the engine from service, but it should raise concern, especially on an engine operating beyond the recommended overhaul period. The operator was already monitoring the oil by means of spectrochemical analysis, but did not recheck the filter. Had the filter been rechecked or the oil analysis completed sooner, the potential for the engine failure would likely have been identified.

The engine failed as a result of oil starvation. Contributing to this failure was the unbalanced propeller, which initiated the progressive fatigue failure of the piston. As a result of the numerous fatigue cracks in the piston wall, the strength of the wall was compromised and pieces broke away, migrating to the bottom of the crankcase. The design of the oil system forced oil under pressure from the crankcase back to the oil tank, causing the failed pieces from the piston to become lodged in and over the return outlet fitting. When the outlet to the oil tank became blocked or restricted, less and less oil was available to lubricate the engine. The engine temperature began to rise and the No. 1 connecting rod failed, striking and fracturing open the right upper surface of the crankcase, and the engine stopped.

The following Engineering Laboratory Report was completed:

LP 101/00—Engine Examination.

## *Findings as to Causes and Contributing Factors*

6. The rotation of the unbalanced propeller produced vibrations that were transmitted to the engine through the engine gearbox propeller shaft and that contributed to the fatigue failure of the No. 1 piston.

7. The No. 1 piston failed in progressive fatigue and produced debris that restricted the return oil flow to the oil tank. This starved the engine of lubricating oil and caused the engine to fail.

8. The results of the oil analysis were not received in a timely manner, which contributed to the operator continuing to use the engine in a state of degrading airworthiness.

## *Safety Action*

Following the occurrence, the operator initiated the following changes:

1. Three engines were replaced as a precaution against further defects.
2. Rotax engines are now operating on the recommended automobile fuel (mogas).
3. Propeller balance is now checked every 200 hours.
4. Oil sample analysis is now carried out in a more timely manner.

The propeller manufacturer recommends that the propellers be maintained by a Hoffman authorized service station to avoid incidents such as an unbalanced propeller.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 08 November 2001.*