Report 01-009

Bell 206B Jetranger

ZK-HWI

perceived engine power loss and heavy landing after take-off

Mount Pisa Station 15 km northeast of Cromwell

11 September 2001

Abstract

On Tuesday, 11 September 2001, at about 1130, ZK-HWI, a Bell Jetranger 206B II helicopter took off normally for a chemical spraying flight. On board the helicopter were an instructor pilot and a trainee who was the pilot flying the helicopter. Shortly after take-off, when the helicopter was climbing away, the drive to the engine power turbine tachometer generator failed, causing the power turbine gauge indication to decrease. The instructor pilot, believing the helicopter was losing power, immediately took control of the helicopter and instinctively lowered the collective lever. The helicopter descended and impacted the ground heavily with some forward speed, before lofting back into the air and again descending to the ground. The helicopter was extensively damaged. The 2 pilots were uninjured.

A safety issue identified was the need for the helicopter maintenance company, in conjunction with operators it provides services for, to establish a robust system that ensures any additional maintenance due is recorded correctly, so additional maintenance is completed fully at the earliest opportunity.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Bell 206 ZK-HWI

Contents

Figures

List of abbreviations

km	kilometre(s)
N_1	gas producer turbine speed
N_2	power turbine speed
N_R	rotor speed
UTC	Universal Coordinated Time

Data Summary

Aircraft registration:	ZK-HWI
Type and serial number:	Bell 206B II, 1685
Number and type of engines:	one Rolls-Royce Allison 250-C20
Year of manufacture:	1975
Operator:	Helicopters Otago Limited
Maintenance company:	Airwork South Island Limited
Date and time:	11 September 2001**,** 1130[1]
Location:	Mount Pisa Station 15 km northeast of Cromwell latitude: 44° 55´ south longitude: 169° 17´ east
Type of flight:	commercial transport agricultural
Persons on board:	crew: 2 passengers: none
Injuries:	crew: nil passengers: nil
Nature of damage:	substantial to the helicopter
Pilot in command's licence:	Commercial Pilot Licence (Helicopter)
Pilot in command's age:	52
Pilot in command's total flying experience:	approximately 19 500 (3000 hours on type)
Investigator-in-charge:	K A Mathews

[1] Times in this report are New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24-hour mode.

1. Factual Information

1.1 History of the flight

1.1.1 On Tuesday, 11 September 2001, at about 1130, ZK-HWI, a Bell Jetranger 206B II helicopter, took off from Mount Pisa Station 15 km northeast of Cromwell for an agricultural chemical spraying flight. An instructor pilot and a trainee pilot were on board the helicopter.

1.1.2 The helicopter was on its 10th spraying flight of the morning and was carrying a standard pre-mixed and pre-measured chemical load. Two more loads remained to complete the spraying work. The take-off path was clear of any obstacles and over a level grass field. The weather conditions were clear skies with up to 3 knots of wind reported along the take-off path of the helicopter, giving it a head wind component for the take-off.

1.1.3 The helicopter had performed normally throughout the morning and during previous flights. The pilots had not noticed anything untoward with the helicopter and were not concerned about its performance. The trainee pilot had completed several solo flights immediately prior to the accident flight without incident, with the instructor pilot re-boarding the helicopter at the start of the accident flight. Before the accident flight the instructor pilot added 20 litres of fuel to the helicopter fuel tank.

1.1.4 With the trainee pilot flying, the helicopter took off normally, went through translational lift and climbed away. The helicopter loader saw ZK-HWI depart normally and did not notice anything untoward, until the accident. At about 40 or 50 feet above the ground and around 50 knots indicated airspeed, the trainee pilot lowered the collective lever and reduced power from 100% torque to about 90% torque. At the same time the instructor pilot, who was sitting in the left seat and looking out his left windshield toward the spraying area, sensed the power reduction and looked into the cockpit. He noticed the power turbine speed (N_2) indicator steadily decreasing and approaching 80%[2]. Believing the engine was losing power, as though the throttle was being smoothly rotated to the closed position, he immediately took control of the helicopter and put his hand on the throttle and confirmed it was fully open. He lowered the collective lever and activated the rotor speed (N_R) selector switch (beep switch) to ensure it was fully "beeped" to maximum N_R.

1.1.5 The instructor pilot later advised that during his flying career he had experienced N_2 or similar gauge failures in both aeroplanes and helicopters. In each case gauge needle flickering had preceded a sudden needle drop. He said with ZK-HWI the steady decrease in the N_2 indication was not indicative of a gauge failure, but of an engine or transmission drive problem, thus necessitating an emergency run on landing.

1.1.6 The trainee pilot later said he had not sensed any power loss or felt the helicopter yaw. After the instructor pilot had indicated a power loss and took control the trainee pilot noticed the N_2 gauge indication at around 80%. Neither pilot recalled seeing the N_R indication decrease. The pilots did not hear any audio warnings, or see any warning lights for low N_R or low gas producer turbine speed (N_1).

1.1.7 During the descent the instructor pilot directed the trainee pilot to jettison the chemical load. The helicopter landed heavily but straight with some forward speed and slid through an open gateway. The skids struck a rut and the helicopter lofted back into the air some 40 feet, rotated about 270° and descended to the ground. The helicopter came to rest upright in an irrigation ditch with the throttle fully open and the engine running. The pilots shut the engine down by moving the fuel selector to the off position. The throttle was later found still in the fully open position during the site inspection. No fire occurred. The pilots were uninjured.

[2] N_R and N_2 are displayed on a dual gauge. The gauge needles are normally joined and remain constant at the selected value (usually 100%), regardless of power changes.

1.2 Crew information

1.2.1 The instructor pilot was aged 52. He held a Commercial Pilot Licence (Helicopter) and a Class 1 Medical Certificate valid until 6 November 2001. He was a D and E category instructor. He was endorsed to carry out helicopter agricultural, chemical, sling and night operations. His various helicopter type ratings included the Bell 206. He had flown approximately 19 500 hours, including 3000 hours in Bell 206 helicopters.

1.2.2 The trainee pilot was aged 28. He held a Commercial Pilot Licence (Helicopter) and a Class 1 Medical Certificate valid until 14 November 2001. His various helicopter type ratings included the Bell 206. He had flown approximately 236 hours, including 84 hours in the Bell 206 type.

1.3 Helicopter information

1.3.1 ZK-HWI was a Bell 206B II single-engine helicopter, serial number 1685, constructed in the United States in 1975. A Rolls-Royce Allison 250-C20 engine, serial number CAE 823329, was fitted to the helicopter.

1.3.2 The helicopter records showed the helicopter was maintained in accordance with the operator's approved maintenance programme. At the time of the accident the helicopter had amassed 10 589.2 airframe and engine hours. The last maintenance check was a 300-hour inspection completed on 16 August 2001 at 10 545.6 airframe hours. The next check, a 100-hour inspection, was due at 10 610.6 airframe hours or on 16 August 2002, whichever occurred first.

1.3.3 On 17 March 2001, the company that maintained ZK-HWI sent a maintenance engineer to carry out field maintenance on the helicopter. The engineer replaced the N_2 tachometer generator with a serviceable unit, because there was no N_2 indication on the dual N_R and N_2 gauge.

1.3.4 The engineer said he also assessed the N_2 tachometer generator drive shaft receptacle on the accessory gearbox to be worn but serviceable. He inserted red coloured RTV (an aviation sealant) into the receptacle to prevent fretting and any further wear or slippage, until the receptacle could be replaced at the soonest opportunity. The engineer later said that it was not unusual to find wear in the generator drive shaft receptacles, because the drive shafts did not normally fit snugly into the receptacles, and some movement resulted.

1.3.5 Normal N_2 gauge indications returned after the maintenance and the engineer did not receive any further reports of unusual N_2 indications. The engineer had intended to replace the generator drive shaft receptacle at the next scheduled servicing. In order to replace the receptacle, which formed part of a gear in the accessory gearbox, the engine had to be removed from the helicopter and the accessory gearbox opened.

1.3.6 The engineer recorded the maintenance action on a company work record sheet for the helicopter, which formed part of the helicopter logbook records, but he did not record the need to subsequently replace the drive shaft receptacle. The engineer said he overlooked transferring the requirement to replace the receptacle to the additional maintenance due section on the maintenance advice form, and consequently he did not remember to complete the action. There was no loose leaf or direct entry made in the helicopter aircraft logbook concerning the N_2 tachometer generator replacement. Neither the pilot at the time, nor the engineer, made any entry in the aircraft technical or daily flight log carried in the helicopter, and the operator was only verbally made aware of the need to replace the receptacle. Pilots are required by Civil Aviation Rules to record any defect found during a flight in the technical log, and an engineer should also record the rectification action taken and maintenance due in the log. The N_2 generator drive shaft receptacle was not replaced during the next scheduled servicing, which occurred on 27 March 2001, or during subsequent servicings.

1.3.7 An engine out warning system provided a visual and audible indication of an engine out condition. An engine speed sensor was attached to the N_1 tachometer generator. A caution panel warning light would illuminate and an overhead console warning horn would sound, when the N_1 dropped below 55 (±3) %.

1.3.8 There was no visual and audio warning system for a low N_2 condition.

1.3.9 An N_R low caution system provided a visual and audible indication of low N_R. A caution panel light would illuminate and a warning horn in the right headliner would sound, when the N_R dropped below 90 (±3) %.

1.4 Wreckage and impact information

1.4.1 The helicopter was substantially damaged in the accident. One main rotor blade had fractured in overload, about one-third of the blade length in from its tip. The fracture followed a rotor strike after the helicopter descended to the ground after having lofted back into the air. The main rotor system separated from the main rotor mast when the rotor mast fractured in overload directly under the raised boss near the rotor head. The main rotor head had bumped the rotor mast at the raised boss. The transmission broke away from its mounts and came to rest in front of the helicopter. The short shaft decoupled and fractured at its attachment to the transmission. The tail rotor drive shaft had failed in torsional overload, following a sudden stoppage of the tail rotor when being driven under power. The helicopter came to rest in a shallow irrigation ditch, leaning partially on its left side. The tail boom buckled downwards immediately aft of where it attached to the fuselage.

1.4.2 The engine continued to run after the helicopter came to rest, in spite of having ingested some debris when the transmission broke away. With the throttle fully open the governor was designed to control the engine speed to maintain 90% to 100% N_2 if there was a loss of engine load, such as if the short shaft decoupled from the transmission.

1.5 Tests and research

1.5.1 The helicopter was transported to a maintenance facility for examination.

1.5.2 The fuel supplied to the helicopter was not contaminated and met the required specifications. Examination of the helicopter fuel system did not reveal any deficiencies or fuel contamination. There was adequate fuel available to the engine. All filters and screens were clean. There were no fuel leaks. The fuel venting system was not blocked.

1.5.3 All fittings to the engine were secure. The control linkages were intact and rigged correctly. The engine turned freely and no mechanical defects were evident. A pneumatic air pressure test did not reveal any leakages in the pneumatic system. Some light first-stage and second-stage compressor blade damage resulted from the ingestion of aluminium debris during the accident.

1.5.4 The engine was removed from the helicopter and shipped to Melbourne to run on a test stand under the Commission's and the engine manufacturer's supervision.

1.5.5 The engine was inspected before fitting to the test stand. The compressor blade damage was not sufficient to have caused any significant loss of performance, or prevent the engine test stand run. Some aluminium splatter was evident in the hot section, indicating the engine was running when it had ingested the aluminium debris. A further pneumatic air pressure test did not reveal any leakages in the pneumatic system. Both engine chip plugs were clean.

1.5.6 The N_1 and N_2 tachometer generators were removed from the accessory gearbox. The tachometer generators had square-shaped drive shafts attached, which fitted into corresponding normally square-shaped drive receptacles on gears in the accessory gearbox. (See Figure 1) The drive receptacles normally rotated the generator drive shafts. The N_2 tachometer generator drive shaft receptacle had red coloured RTV inserted in it. This had been inserted on top of some brown aviation sealant. The RTV was not adhering to the N_2 tachometer generator drive shaft and it fell away from the shaft as it was removed from its receptacle. The drive shaft was polished on each of its 4 corners, indicating that its receptacle had been rotating around the shaft instead of driving it. The drive receptacle was rounded instead of square-shaped. The N_2 tachometer generator drive shaft was reinserted into its receptacle and the engine rotated. The receptacle rotated around the drive shaft and did not turn the shaft and drive the N_2 tachometer generator, as it should have. The N_2 tachometer generator was tested separately and operated normally.

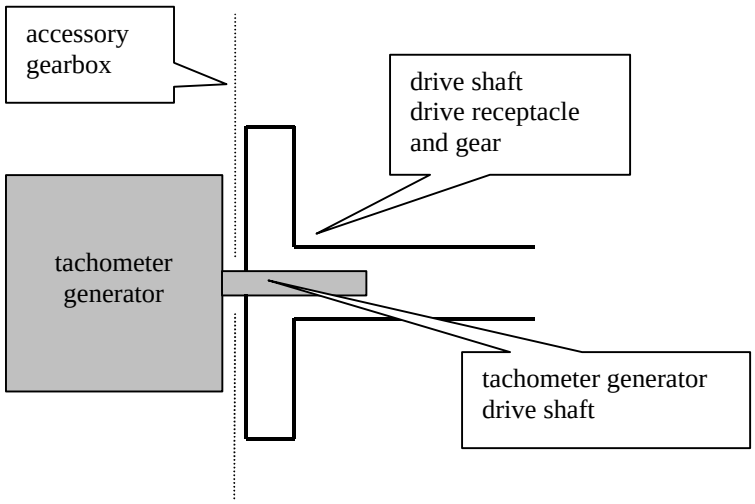

Figure 1. Tachometer generator and drive mechanism

1.5.7 The engine started normally on the test stand and ran satisfactorily throughout its power range. Several engine runs were completed normally, including rapid acceleration and deceleration tests. The engine was well within the required specifications for the acceleration and deceleration tests. At maximum power the engine performance was down slightly because of the foreign object damage to the compressor blades. This performance loss was not significant and the engine delivered more power than rated for the main transmission. No anomalies were detected that may have contributed to a power loss, or intermittent power loss.

2. Analysis

2.1 Examination of the accident circumstances and the failed helicopter components, such as the overload failures of the main rotor mast, short shaft, main rotor blade, and torsional overload of the tail rotor drive shaft, indicated the helicopter engine was delivering significant power at impact. During the separate engine tests the engine ran normally, and the tests revealed the engine was capable of delivering normal power prior to the accident. There was no evidence supporting any power loss or intermittent power loss. Nothing was found in the fuel delivery or other ancillary systems that could have contributed to an engine power loss. There was, though, evidence of an N_2 tachometer generator drive failure.

2.2 The trainee pilot was the pilot flying the helicopter during the take-off and departure immediately before the accident, with the experienced instructor pilot seated in the left seat and not manipulating the controls. The trainee pilot was a trainee for the purpose of gaining an endorsement for agricultural chemical spraying. He was already a professional pilot and qualified to fly the helicopter. The instructor pilot was giving specific agricultural spraying instruction and supervising the trainee pilot's solo flights.

2.3 The departure path was clear of obstacles and over a level grassed paddock, in clear weather conditions. The instructor pilot understandably did not directly monitor the trainee pilot's handling of the helicopter, or the helicopter systems, during the take-off. Rather, the instructor pilot was looking left toward the spraying area, with his attention focused more on planning the actual spraying flight than monitoring the departure.

2.4 The trainee pilot's attention was naturally outside the cockpit during the departure, and shortly after take-off he lowered the collective lever normally to reduce power. The instructor pilot, with his attention focused on the spraying area, sensed or heard the power reduction and turned his head to the right and glanced into the cockpit. At the time the trainee pilot reduced power, or shortly before, the N_2 tachometer generator drive failed causing the N_2 gauge indication to decrease, thus indicating a loss of N_2. The instructor pilot saw the N_2 indicator decreasing steadily toward 80% and, having just sensed a power change, immediately thought the engine was losing power, or that there was a transmission drive problem. His belief was reinforced by his previous experience of gauge failures, which were dissimilar to this situation. He quickly took control and responded correctly to what he believed was an engine power loss, or transmission drive problem, shortly after take-off.

2.5 At 50 feet (15 metres) or less above the ground the pilots had little opportunity to cross-reference other cockpit instruments and note the lack of supporting evidence for an engine failure situation, or transmission problem. The pilots did not hear or see any cockpit warnings supporting a power loss, because there was no loss of N_R or N_1. The pilots also did not feel any helicopter yaw, because the engine had not lost power. Shortly after the instructor pilot took control of the helicopter and responded instinctively to what he perceived to be a power loss, or transmission problem, the helicopter had descended onto the ground. If the N_2 tachometer generator drive failure had occurred when the helicopter was higher above the ground, the outcome may have been different. The pilots would probably have detected the erroneous N_2 gauge indication in time for them to recover the situation. Alternatively, if the pilots had first seen the N_2 indication at zero with the engine still delivering power, then it would have been immediately obvious the gauge indication was erroneous.

2.6 The N_2 tachometer generator had been replaced during field maintenance 6 months before the accident, and RTV was placed in the drive receptacle to prevent any fretting and any further wear or slippage. The maintenance engineer said he intended to replace the drive 10 days later during the scheduled helicopter servicing. The drive receptacle replacement could not be accomplished in the field because of the complexity of the work. The engineer recorded the defect and the rectification action taken on the appropriate work record sheet but did not transfer this information to other appropriate records. Because the required subsequent action was not recorded in the maintenance work pack as additional maintenance due on the company maintenance advice form, nor in the helicopter technical log, and because there had been no further reports of erroneous N_2 gauge indications, the drive receptacle replacement was overlooked during subsequent servicings. Consequently, the RTV deteriorated over time and failed to prevent further wear, or failed to continue to assist in maintaining a positive drive, between the N_2 tachometer generator drive shaft and its receptacle, until slippage between them occurred. On the accident flight, the drive failed causing the N_2 gauge indication to decrease.

2.7 If the pilot at the time had recorded the initial defect in the technical log carried in the helicopter with the engineer recording the maintenance action, which were required, the operator could have been alerted to review the defect circumstances and rectification action. If another similar entry recording the need to subsequently replace the drive shaft receptacle had been made, the operator, being responsible to ensure correct maintenance, could have been alerted directly to the requirement. The operator having been only told of the additional maintenance necessary was not prompted to remind the maintenance company about the initial defect with the need to replace the receptacle, and to ensure this was completed.

2.8 The helicopter maintenance company and operator needed to establish a robust system that ensured any additional maintenance due was recorded correctly, so that any required follow-up action after field maintenance was brought to the attention of the responsible personnel for action. Had there been such a system in place ensuring correct maintenance recording, the N_2 tachometer generator drive receptacle probably would have been replaced and this accident prevented.

3. Findings

Findings and safety recommendations are listed in order of development and not in order of priority.

3.1 The N_2 tachometer generator drive failed shortly after take-off, which caused the N_2 gauge indication to decrease and infer a loss of engine power, or transmission drive problem.

3.2 The instructor pilot did not have sufficient time to confirm the failure, and took the appropriate and immediate action necessary in response to what he perceived to be an engine power loss, or transmission problem, during a critical phase of flight.

3.3 The follow-up action necessary after field maintenance to the N_2 tachometer generator drive was overlooked, and the drive remained in service until it deteriorated and failed.

3.4 The maintenance company and operator did not have a suitable system in place to make certain that any additional maintenance action required following field maintenance was recorded correctly and completed at the next available aircraft servicing.

4. Safety Recommendation

4.1 On 20 March 2002 the Commission recommended to the Quality Assurance Manager for Airwork New Zealand Limited that he:

> establish a system, in conjunction with any operators for whom Airwork provide maintenance services, that ensures any follow up maintenance action necessary after any maintenance, is correctly recorded and carried out at the appropriate time. (013/02)

4.2 On 22 April 2002 the Quality Manager for Airwork (NZ) Limited replied, in part.

> Please be advised that all corrective actions as recommended by your report and the internal Airwork NZ Ltd safety investigation report dated 5 March have now been completed.

The company Standard Practice Instruction **(SPI 802.7.3), Servicing Advice Notice-Form AWS 5** dated 19/04/02, has been amended to include the requirement to inform the Operators Maintenance Controller by faxed copy of the completed AWS Form 5, and:
SPI 802.7.6, Rectification of deferral of defects has also been amended to include an additional paragraph to identify that: **All in service defects away from main base shall be recorded in the Operators approved Technical Log and an Airwork South Island AWS Form 5 document.**

Approved for publication 05 June 2002

Hon. W P Jeffries
Chief Commissioner