ACCIDENT

Aircraft Type and Registration:	Rotorway Executive 162F, G-JDHN
No & Type of Engines:	1 Rotorway RI 162F piston engine
Year of Manufacture:	1998 (Serial no: 6324)
Date & Time (UTC):	2 April 2021 at 1500 hrs
Location:	Near Ledbury, Herefordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Helicopter damaged beyond repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	Approximately 300 hours (of which 80 were on type) Last 90 days - not declared Last 28 days - not declared
Information Source:	AAIB Field Investigation

Synopsis

The helicopter was in a stable cruise when the pilot heard a very loud noise which may have been caused by unburnt fuel igniting in the exhaust. This resulted in the helicopter reacting in a way that the pilot could not rationalise in the short time available, so he successfully autorotated to land in a field. At the end of the ground run, the left skid caught on uneven ground and the helicopter rolled over onto its left side. Both the pilot and passenger managed to escape with minor injuries.

It is suspected that defects in the cylinder 3 exhaust valve sealing may have been the cause of unburnt fuel in the exhaust system.

History of the flight

At around 1400 hrs on the day of the accident, the pilot prepared the helicopter for a flight to the Brecon Beacons National Park. Earlier in the day he had flown a training sortie in a Bell B206 JetRanger at Shobdon Aerodrome, and the weather had been fair, but he noticed that cloud was starting to build to the west. Consequently, he planned to route east towards the Malvern Hills where the weather was generally fair with light winds from the northeast. After takeoff, the helicopter was established in a cruise at 1,500 ft and 80 mph and the pilot turned towards Ledbury (Figure 1) to route along the Malvern Hills from south to north.

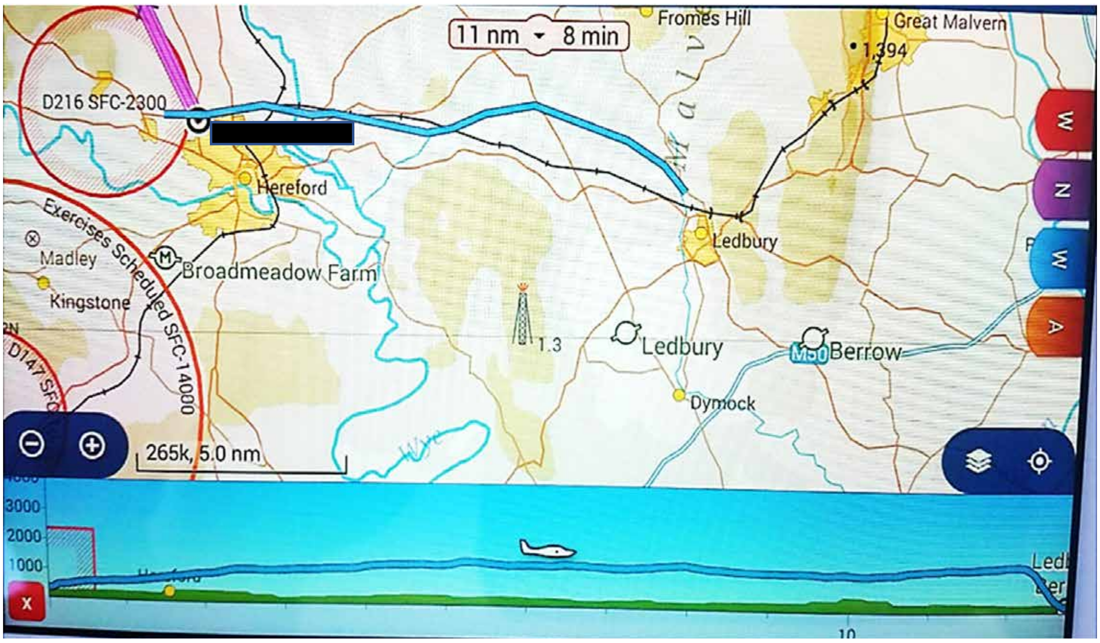


Figure 1

G-JDHN's recorded track from SkyDemon application
(used with permission)

As he approached Ledbury, the pilot reported hearing an "almighty bang" that appeared to come from the rear of the helicopter. The noise was sufficiently loud to be described by witnesses on the ground as sounding like an "explosion". The pilot stated that the helicopter "twitched" in yaw to the right as though it had been pushed and then pitched nose up rapidly. His immediate thought was that drive to the tail rotor had been lost but he was confused why the helicopter yawed in the opposite direction to which he expected. He levelled the attitude then entered autorotation by lowering the collective lever. The engine indications appeared normal. The pilot noted that he had applied full left yaw pedal but there appeared to be no response in yaw. He also noticed that the rotor rpm was indicating at the top of or just outside the gauge's arc at 110%.

He assessed the position of the collective lever to be approximately the same as during takeoff and, consequently, expected the rotor rpm indication to be lower. He raised the collective lever further in an attempt to reduce rotor rpm but was concerned that it might reduce it too much. He considered the possibility of a false indication on the gauge so decided to maintain the current collective lever position and focus on reaching the field he had selected for landing.

During the descent the pilot recognised that he was heading towards some polytunnels, so he turned away from them onto a southerly heading. He noted there were power cables in the new approach path but was confident that his glide angle would clear them. He reported having no response from the tail rotor. The pilot flared the helicopter and landed on the rear half of the landing skids at a "walking pace". During the ground run, the front of the left skid dug into a rut in the ground causing the helicopter to pitch forward and roll over onto its left side, after which it came to rest facing north (Figure 2).

Figure 2
G-JDHN at the accident site (used with permission)

The pilot evacuated the helicopter and assisted the passenger to escape through the front of the cockpit. Whilst he was doing this, he noticed that fuel was leaking from the right fuel filler cap which had been damaged during the landing. Emergency services arrived on scene quickly having been alerted by eyewitnesses on the ground. The pilot and the passenger were taken to hospital for evaluation of their minor injuries.

Accident site

The accident site was in a fallow field approximately two miles to the north of Ledbury. The grass was short, but the ground was uneven with some holes. The helicopter was lying on its left side with the tail structure broken in several pieces, although the tail rotor section was still attached by a control cable. Various loose bits of tail structure, including sections of drive belt, were scattered a short distance to the south of the fuselage. The helicopter remained on its left side for approximately two hours until it was recovered back to the pilot's private helipad.

Recorded information

The primary and secondary Dual Engine Control Units (DECUs) record many engine parameters once a second. The available data was downloaded and three significant parameters, from the primary DECU, were plotted against time since engine start (Figure 3).

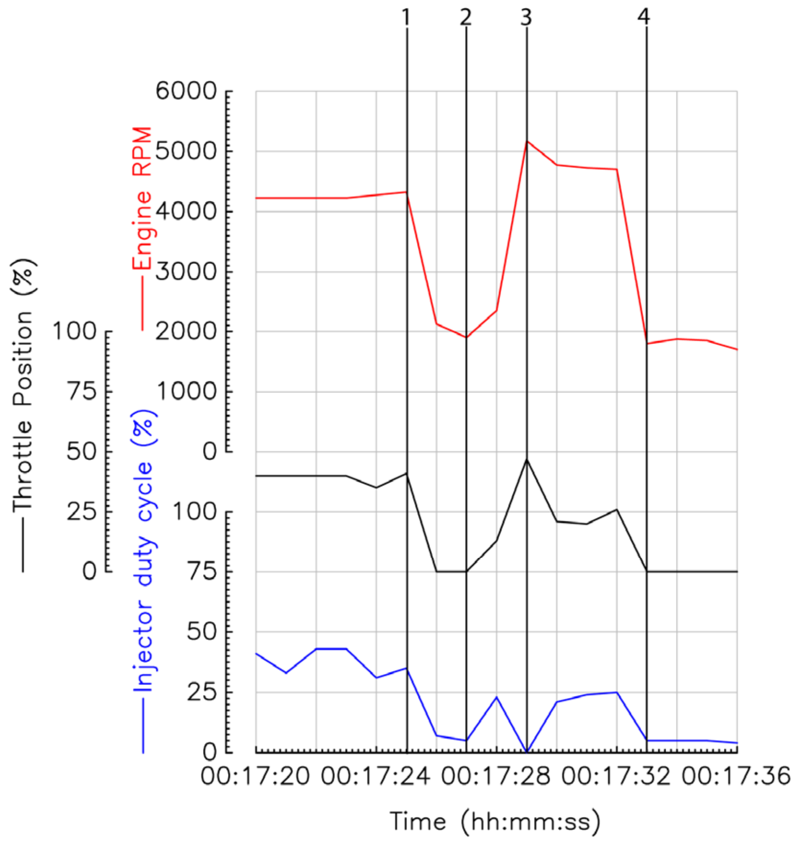


Figure 3

Primary DECU download of the significant parameters

The helicopter was in the cruise with all parameters stable up until 00:17:25 where it is considered that the bang occurred (1). Two seconds later the throttle was closed to zero and the engine speed reduced accordingly (2). A further two seconds later the throttle was opened to just above cruise setting, but the engine speed reached 110% (5,175 rpm) and the engine limiter initiated by cutting the injector duty cycle to zero (3). Over the next four seconds the throttle was adjusted and eventually closed (4), and it remained in that position until the fuel was shut off and the engine stopped several seconds before the landing.

Aircraft information

G-JDHN was a light homebuilt helicopter from a premanufactured kit with a vertically mounted four-cylinder engine driving the main and tail rotor, and the engine accessories. It was built in 1998 and had flown 674 hours, the second highest of all the 162F helicopters on the UK register. It had previously been registered as G-FLIT and was the subject of a 2013 AAIB accident report[1]. In the AAIB database there are 27 reports of Rotorway helicopter accidents and incidents between 1980 and publication of this report, of

Footnote

[1] https://assets.publishing.service.gov.uk/media/54230296ed915d1374000b3b/Rotorway_Executive_162F_G-FLIT_02-13.pdf [accessed 23 March 2022].

which 14 have involved an emergency landing that ended with the helicopter rolling over. The latest evolution of the 162F, the Talon, has much stronger landing gear with longer skids.

The cabin of the 162F is a composite construction with space for two people to sit side by side. The analogue instruments are laid out on the central console with additional gauges in front of the left (pilot's) seat (Figure 4 left). The rotor and engine speed are displayed side by side, in percent, on a dual gauge (Figure 4 right).

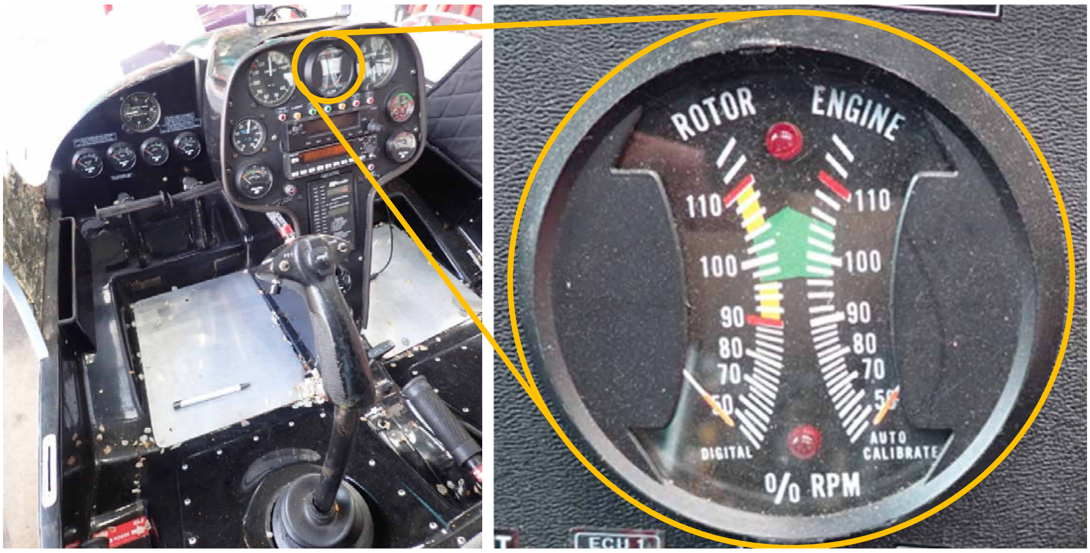


Figure 4

G-JDHN cockpit layout (left) and rotor / engine combined rpm gauge (right)

The throttle is operated by a twist grip on the collective lever to the left of the pilot's seat. There is no mechanical or electronic automated control of the throttle when moving the collective lever and so the pilot must manually account for any collective movements with a change in throttle position to maintain the engine speed in the green arc.

The flat-four engine (Figure 5) was designed and built specifically for the 162F helicopter and is installed with the crank shaft oriented vertically. The engine has two valves per cylinder and is water cooled. Fuel metering and timing is controlled by a primary DECU which uses various sensors to ensure optimal running. A secondary DECU, using pre-programmed default values instead of sensor data, is installed in case of a failure of the primary DECU. The drive from the crankshaft is transferred to a secondary drive shaft by four V belts in parallel, with a movable spring-loaded third pulley wheel which is operated as a clutch during start up. The pulley wheel tensions the drive belts by an over centre linkage operated by the pilot pushing on a steel T-handle lever in the cabin bulkhead (Figure 6). Drive to the main rotor head from the secondary shaft is via a triplex drive chain whilst external engine accessories, such as alternator, cooling fan and water pump, are driven from separate V belts. The exhaust pipe from the four cylinders has a single silencer and tail pipe suspended beneath the tail boom.

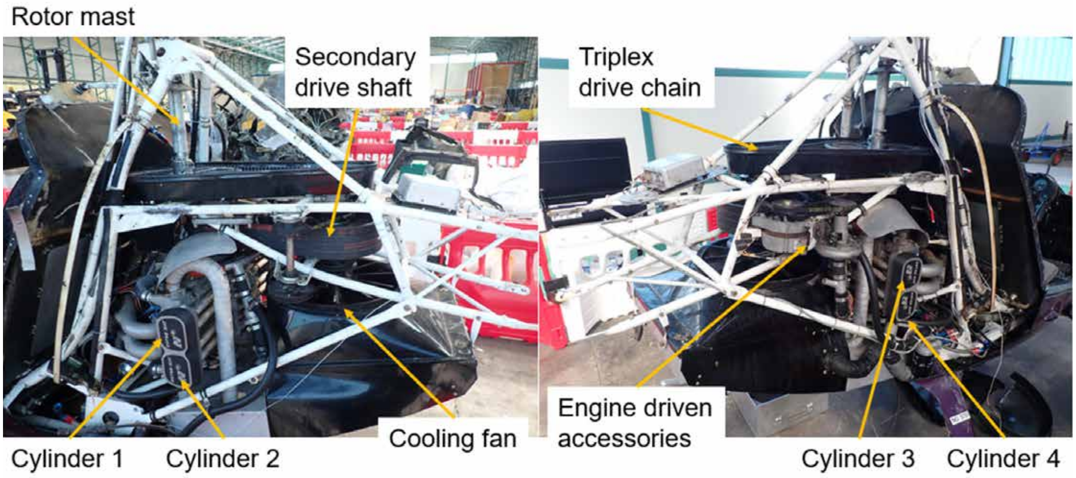


Figure 5

G-JDHN engine layout. Helicopter left side (left) and right side (right)

Figure 6

Cockpit looking aft with clutch lever disengaged

Drive to the tail rotor is via three V drive belts in series from the secondary drive shaft (Figure 7). The secondary drive shaft is vertical, but the tail rotor drive shaft is horizontal, so there are two intermediate pulleys aligned 30° from the previous pully thereby rotating the drive. All three belts in the system are tensioned by adjusting the position of the last pulley, and the belt tension is checked by the pilot as part of the pre-flight inspection using a special tool to verify 1⅜” deflection with 10 lb of force applied.

The tail drive belts on G-JDHN were replaced during annual maintenance in February 2020, and they were inspected and had their tension checked in February 2021 with no defects found. The belts had accumulated 43.8 hours of operation by the time of the accident flight, well within the replacement requirement of 250 hours or two years.

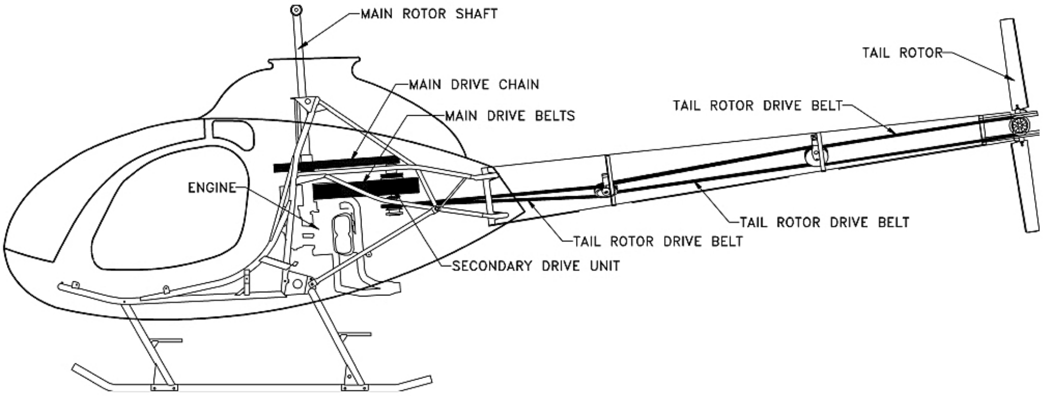


Figure 7

G-JDHN Rotor drive system

The helicopter was maintained in accordance with the manufacturer's prescribed schedule and had its last annual check four flying hours prior to the accident flight in February 2021. The helicopter had completed 673 hours and had an engine top end overhaul at 494 hours. The overhaul of the cylinder heads was undertaken by the manufacturer, but no records of the work carried out could be obtained. A cylinder compression test was carried out during each annual check and every year it had passed. The results from the test in February 2021 are included in Table 1 with the pass criteria of 68 psi minimum.

Aircraft examination

The helicopter was recovered from the pilot's private helipad to the AAIB for further inspection. No pre-existing defects were found with the main rotor drive train, flight controls or external engine accessories. It was noticed that the lock barrel of the right fuel cap was missing. The main body of the cap was still in place, but with the barrel missing it would no longer seal the fuel filler pipe. The body of the cap was undamaged.

The tail boom structure was badly damaged with the tail rotor assembly and vertical fin having broken off as one piece (Figure 8 left), leaving approximately 30 cm attached to the fuselage structure. The lower skid and the upper vertical fin of the tail rotor assembly showed signs of impact with the ground, and there was minor damage to the tail rotor blades from ground contact including the loss of a blade end cap. The rest of the structure had broken into many smaller pieces including the two aluminium castings that supported the intermediate pulleys (Figure 8 middle). On both intermediate pulley wheels there were impact marks and soil lodged into the V grooves. The temperature stickers on the pulleys had not recorded an increase in temperature during operation. All three tail rotor belts had been damaged and the third (nearest the tail rotor) was in two pieces. The belts were examined and were in good condition with no indications that the belts had been slipping or of any other defects. The damage to the ends of the belts was consistent with overload failure (Figure 8 right).

Figure 8

Tail rotor, intermediate pulley and drive belt damage

The engine was inspected, and engine oil was found in the inlet manifold, predominately in the common inlet plenum but also in the manifold for cylinder 1 (upper left) and 2 (lower left). Each cylinder was leak tested with 50 psi air with the engine cold and the piston at top dead centre. The results are in Table 1.

Cylinder	Leak check at 80 psi (Feb 2021)	Leak check at 50 psi AAIB	Comments from AAIB leak test
1	74 psi	44 psi	Air into the crankcase
2	75 psi	39 psi	Air into the crankcase and 1-2 psi inlet valve leak
3	74 psi	34 psi	Air leaking into the exhaust
4	74 psi	44 psi	Air into the crankcase

Table 1

Results from the cylinder leak tests

The cylinder heads were removed, and engine oil was found in all cylinders but there was no readily visible evidence to explain the leak test results. The inlet valve from cylinder 2 and the exhaust valve from cylinder 3 were removed and examined in detail. The valves and valve seats were examined using an optical microscope at magnifications up to x120. Multiple surface defects were found on both valves and their corresponding seats (Figures 9 to 12).

The width of the contact area between the inlet valve and the seat is approximately 400 µm and the largest surface defect was 640 µm wide, which crossed into the contact area.

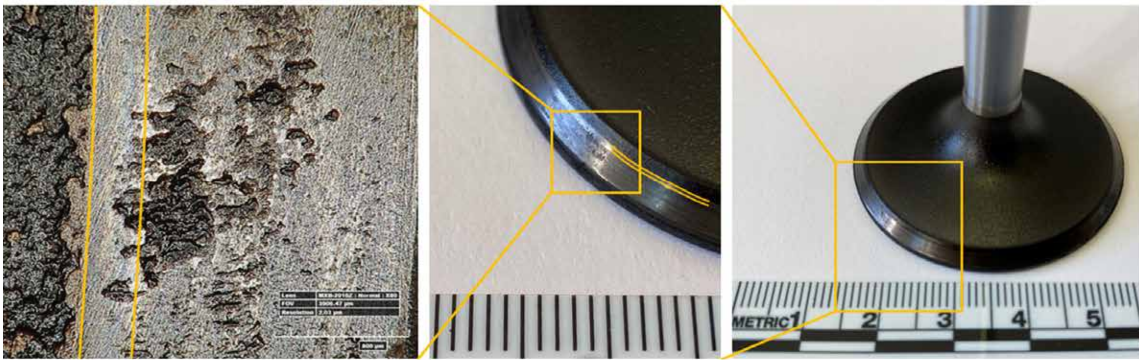


Figure 9

Cylinder 2 inlet valve surface defect, valve seat contact area highlighted

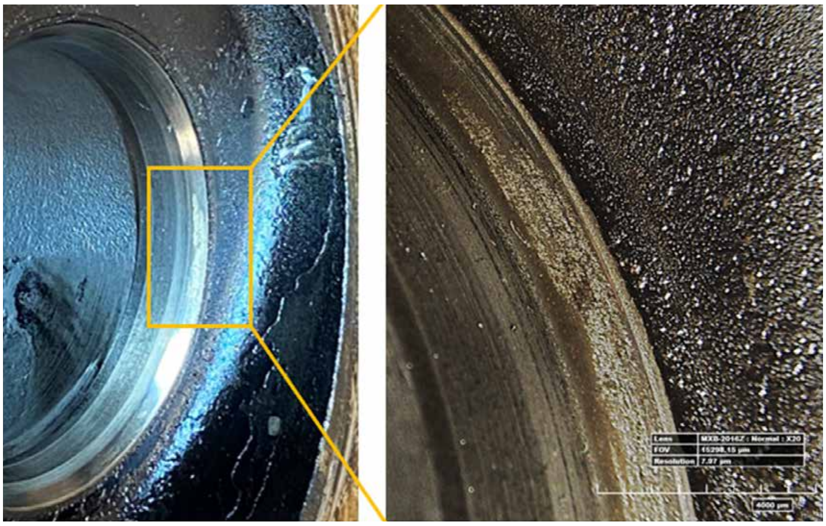


Figure 10

Cylinder 2 inlet valve seat surface defects

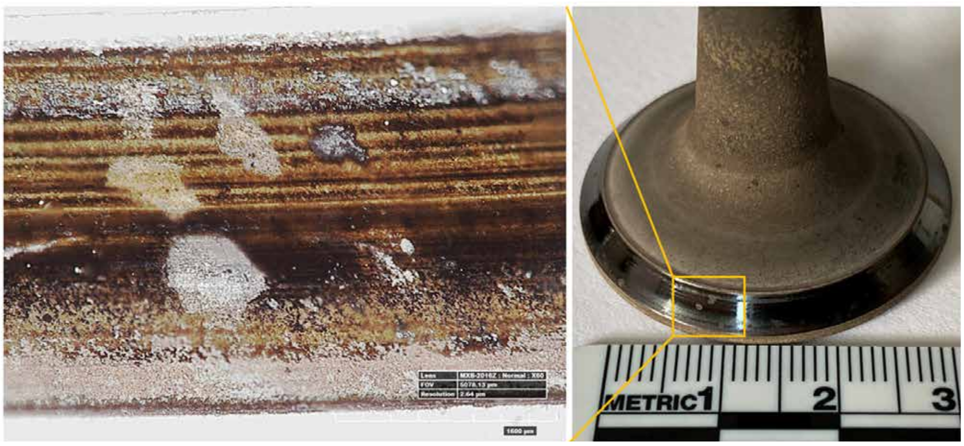


Figure 11

Cylinder 3 exhaust valve surface defects

Figure 12

Cylinder 3 exhaust valve seat surface defects

Survivability

When the helicopter rolled over at the end of the ground run, the passenger in the right seat was injured on the left shoulder by the clutch lever. With the clutch disengaged, the 5 mm diameter steel lever protruded approximately 200 mm into the cabin and was angled towards the passenger side (Figure 6). It could not be determined why the clutch disengaged.

A modification is available to replace the lever and over centre linkage with an electro-mechanical actuator to operate the clutch system.

Personnel

Pilot background

The pilot stated that he started flying in 1993, then after a long break from training he gained his PPL(H) in February 2020, conducting his training on a Robinson R22. He added the 162F to his licence in September 2020. Additionally, he gained a rating on the B206 in April 2021. His total time on these types was approximately 300 hours, of which 80 hours was on the 162F. The pilot did not provide the AAIB with documentary evidence of his hours or recent flying. The pilot had flown the B206 on the morning of the accident flight and reported experiencing no difficulty in switching between helicopter types.

Aircraft performance

Longitudinal oscillation

The 162F is known to exhibit a longitudinal oscillation in the cruise. If disturbed in level flight, the helicopter tends to oscillate in pitch as it attempts to re-establish the conditions from which it was disturbed. This manifests itself to the pilot as the nose pitching up and down with corresponding movement of the cyclic stick which, if left uncorrected, would lead to unstable flight conditions. The 162F pilot learns to 'dampen' the movement by control inputs on the cyclic stick.

Engine failure in cruise

The Flight Manual (FM) contains the following guidance (Figure 13) on dealing with an engine failure and notes that a right yaw and tendency to pitch nose up are characteristics of a loss of power in cruise flight:

12

Section 4. Emergency Procedures

A. Engine failure General:

1. A change in noise level, a right yaw and low oil pressure may be the first indication of an engine failure.

2. Engine failure at high speed, high power, will result in a tendency for the helicopter to pitch nose up.

Figure 13

FM engine failure emergency procedure

Flight Manual guidance on tail rotor failure

The FM or, on later models, the Pilot's Operating Handbook (POH), is issued with each kit and remains with the aircraft. The issue date is checked as part of the revalidation process of the Permit to Fly and any major changes subsequently issued by the manufacturer are included at the front of the manual as an amendment. G-JDHN's FM contained the following entry for a '*tail rotor failure in forward flight'* (Figure 14), stating that a '*right yaw'* would be indicative of a tail rotor failure:

K. Tail rotor failure during forward flight:

1. Failure is usually indicated by a right yaw which can not be corrected by applying left pedal.

2. Immediately enter a shallow descent into the wind.

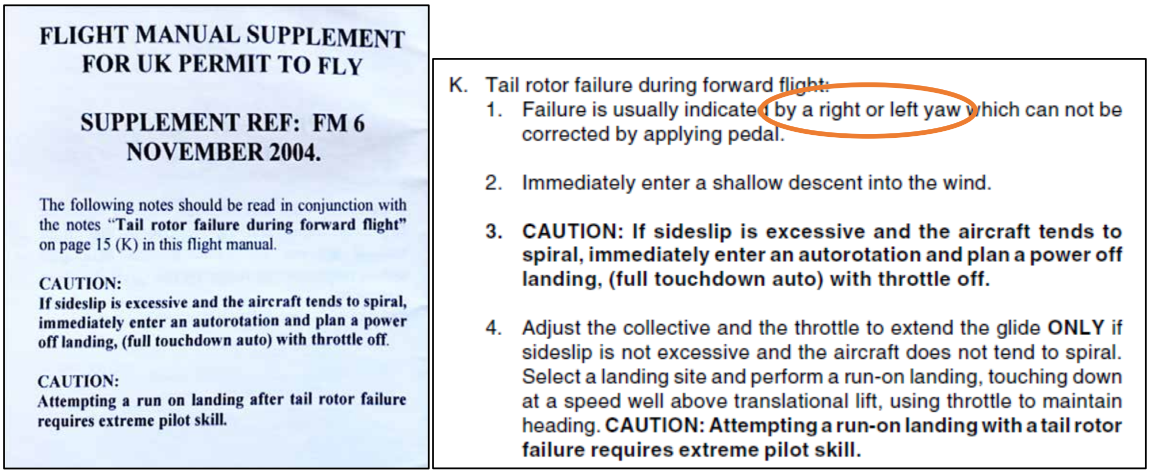
3. Adjust the collective and the throttle to extend the glide if sideslip is not excessive and the aircraft does not tend to spiral. Cyclic and collective are used to limit sideslip angle.

4. Select landing site and perform a run-on landing using throttle to maintain heading.

Figure 14

FM tail rotor failure during forward flight emergency procedure

G-JDHN's FM contained an amendment to this emergency procedure, issued in November 2004 (Figure 15 left).



FLIGHT MANUAL SUPPLEMENT FOR UK PERMIT TO FLY

SUPPLEMENT REF: FM 6
NOVEMBER 2004.

The following notes should be read in conjunction with the notes "**Tail rotor failure during forward flight**" on page 15 (K) in this flight manual.

CAUTION:
If sideslip is excessive and the aircraft tends to spiral, immediately enter an autorotation and plan a power off landing, (full touchdown auto) with throttle off.

CAUTION:
Attempting a run on landing after tail rotor failure requires extreme pilot skill.

K. Tail rotor failure during forward flight:

1. Failure is usually indicated by a right or left yaw which can not be corrected by applying pedal.
2. Immediately enter a shallow descent into the wind.
3. **CAUTION: If sideslip is excessive and the aircraft tends to spiral, immediately enter an autorotation and plan a power off landing, (full touchdown auto) with throttle off.**
4. Adjust the collective and the throttle to extend the glide **ONLY** if sideslip is not excessive and the aircraft does not tend to spiral. Select a landing site and perform a run-on landing, touching down at a speed well above translational lift, using throttle to maintain heading. **CAUTION: Attempting a run-on landing with a tail rotor failure requires extreme pilot skill.**

Figure 15

FM supplement FM6, dated November 2004, and revised POH, dated 2005

The two cautions shown in Figure 15 left were subsequently incorporated into a revised POH issued with aircraft manufactured from 2005 (Figure 15 right). The indication, '*left yaw*' was included as an additional possible indication of a tail rotor failure in forward flight.

The manufacturer was consulted regarding the wording of the original FM and the inclusion of *'left yaw'* in a subsequent POH. They commented that due to the recent change in ownership of the company, they were unable to provide an authoritative answer. They suggested that the original manufacturer may have intended the emergency procedure to be applicable to any tail rotor malfunction, which could include loss of tail rotor authority and control malfunctions, hence the direction of yaw could be in either direction.

Tail rotor

All conventional helicopters require a system to oppose the torque applied to the main rotor head by the engine(s). On the 162F, the rotor head rotates clockwise (when viewed from above) so the torque reaction will cause the fuselage to yaw to the left (anti-clockwise). The tail rotor produces a thrust to counter this effect and to provide the pilot with directional control. An increase in engine torque will therefore require an increase in thrust produced by the tail rotor. This is achieved by the pilot applying right yaw pedal, which will increase pitch on the tail rotor blades, producing more thrust. If drive to the tail rotor is lost, then the helicopter will yaw to the left until the pilot closes the throttle and enters autorotation, thereby removing the applied torque.

The main rotor blades on the R22 and B206 turn anti-clockwise when viewed from above. If drive to the tail rotor is lost on these types, the helicopter will yaw to the right until the pilot takes appropriate action. Therefore, the actions required are the reverse of the 162F.

Main rotor blades

The main rotor blades on the 162F are designed such that when the collective lever is in the fully down position, the angle of the blades is set to negative 2° pitch. The manufacturer stated that this feature was intended to assist the preservation of rotor rpm when entering autorotation. However, supporting documentation for this design intent was not available from the manufacturer for review.

Autorotation

The FM contained the following instruction for entering autorotation (Figure 16):

D. Engine failure above 500 feet AGL:

1. Lower collective to maintain rotor RPM and enter normal autorotation (see page 16).
2. Establish a steady autorotation descent at approximately 65 MPH.
3. Adjust collective to keep rotor RPM 100%.
4. After a steady autorotation is established, select a landing spot and maneuver as required so the landing will be upwind.

Figure 16

FM actions for engine failure above 500 ft AGL

After entering autorotation by lowering the collective lever to the full down position, the rotor rpm increases quickly, and the nose will drop. The pilot must then raise the collective to increase pitch on the blades into the positive range, hence increasing drag to slow them down. Adjusting the position of the collective lever in this way allows the pilot to control and maintain the rotor rpm within the green arc (96 to 104%).

When the collective lever is fully lowered on the R22 and the B206, the main rotor blades do not move to a negative pitch setting. Therefore, the corresponding range of movement of the collective lever, from the full down position to a setting that maintains rotor rpm within an optimal range for autorotation, is less than that required for the 162F.

When established in autorotation there is no significant torque reaction, so the helicopter will tend to yaw in the direction of rotation of the rotor blades due to friction in the drive train. However, as the tail rotor is still being driven and producing thrust, this rotation can normally be controlled by application of yaw pedal in the opposite direction. If main rotor rpm increases beyond the recommended limits, the tail rotor rpm and consequently the thrust it is producing, will increase requiring more yaw pedal input to control. On the 162F, this will require left pedal input to prevent further yaw to the right.

The Flight Manual contains the following note regarding autorotation training:

> *"NOTE:*
>
> *AUTOROTATION TO THE GROUND IS NOT RECOMMENDED DURING TRAINING AND PRACTICE."*

Analysis

Exhaust after fire[2]

The pilot established the helicopter in a steady cruise at 80 mph and 1,500 ft when he heard a very loud noise, which he described as an "almighty bang". Various witnesses on the ground described the noise as sounding like an "explosion". The helicopter was examined extensively for sources that could have produced a noise which could be described as an explosion loud enough to be heard on the ground below.

During the engine examination oil was found in the inlet plenum, and two cylinders leaked air during a leak test. After the helicopter rolled over, it was lying on its left side with cylinders 1 and 2 lowest. The helicopter remained in this attitude for approximately two hours before it was righted and lifted onto a vehicle for recovery. Hot engine oil could have passed the piston rings (a labyrinth seal) and into the cylinder head during this time. The defects in the sealing of the inlet valve in cylinder 2 could have resulted in the oil slowly seeping past the valve and into the inlet manifold and plenum.

The defects observed in the sealing faces of the exhaust valve in cylinder 3 may have allowed unburnt fuel to pass the valve and enter the exhaust system during the accident flight. This unburnt fuel would have accumulated in the exhaust until it was ignited by the exhaust gases and caused an explosion or after fire in the exhaust system. This could have produced a loud noise similar to that described by the pilot and reported by the witnesses on the ground. The after fire would have caused an increase in the internal pressure of the exhaust system which would have momentarily restricted the flow of exhaust from the other cylinders. This restriction would have resulted in a hesitation in power output from the engine.

The cylinder 2 inlet valve and cylinder 3 exhaust valve were in poor condition considering the engine had completed 179 hours since a cylinder head overhaul. It was considered that the defects seen were the result of normal operation of the engine over a prolonged period, where localised heating had resulted in a deterioration in the surface. The maintenance requirement to have a top end overhaul every 500 hours would be to rework any damage before it affected engine performance. It was not possible to obtain the records of the top end overhaul at 497 hours and therefore to determine if any work had been carried out on these valves.

Footnote

2 After fire – The term is used to differentiate between a detonation after the combustion chamber and contained within the exhaust, and a backfire, which occurs in or before the combustion chamber and travels into the inlet manifold.

The compression test carried out during the annual inspection performed four hours before the accident flight did not show any leaking from the valves, whereas the test after the accident showed an appreciable leak from two valves. The tests differed in the air pressure used (80 psi for the annual inspection and 50 psi for the investigation), and the annual inspection test was performed on a hot engine. During normal engine operation the valves are free to rotate, and it is possible that between the annual inspection and the accident, the exhaust valve in cylinder 3 rotated so that a defect in the valve and the head aligned and created a leak path.

Uncommanded right yaw and tail rotor control

The pilot described the helicopter “twitching” to the right then pitching nose up. The investigation could not positively identify the cause of the yaw but considered it possible that a momentary interruption in power, caused by the detonation of unburnt fuel in the exhaust, could produce a transitory yaw to the right. The pilot reported that engine indications appeared to be normal immediately after the noise.

The pilot concluded from the sudden noise and uncommanded yaw to the right that he had lost drive to the tail rotor and consequently entered autorotation and shut off the engine. In the 162F, loss of tail rotor thrust would cause a yaw to the left. The pilot was aware of this apparent contradictory symptom stated that he, but that did not appear sufficient to change his initial diagnosis. There was no evidence to suggest that the wording of the FM influenced his understanding. It is possible that his experience flying the R22 and B206 for approximately 70% of his accumulated hours, where the yaw would be to the right, reinforced his immediate response.

The pilot stated that during the autorotation he applied full left pedal with no response in yaw control. He described the rotor rpm as being at the top, or just outside of the arc, which would also increase the rpm of the tail rotor. The corresponding increase of thrust would have to be countered by a left pedal input to prevent yaw to the right. It is likely that in countering the combined effects of transmission friction and increased tail rotor rpm, left pedal input reached the limits of its travel, reinforcing the pilot’s belief that he had a loss of drive to the tail rotor.

The investigation considered the possibility of a tail rotor drive belt failure but concluded it was unlikely as all three drive belts showed evidence of the same overload failure mechanism. All three belts were in good condition and there was no evidence of the effects of incorrect belt tension which often precedes a belt failure. The belts were new, the tension had been checked recently by the maintenance and repair organisation and the pilot prior to the flight, and the temperature indicators on the pulleys did not show elevated temperatures. It was considered that an inflight failure of the drive belts would not have produced a noise consistent with the description by the pilot and the witnesses on the ground. The increase in tail thrust and inability to apply enough left pedal further suggests the tail rotor was still operational throughout the flight.

Pitch up

The FM stated that an engine failure at high speed and high power would result in a tendency for the nose of the helicopter to pitch up. However, it is not clear to what extent this would occur following a transitory loss of power.

The unexpected loud noise may have induced a ‘startle’ effect on the pilot, causing him to relax his grip on the cyclic stick. The longitudinal oscillation at cruise speed would have caused the nose to pitch up if it was not damped by the pilot. It is possible that the marked pitch up the pilot reported was caused by a combination of these two factors.

Throttle limiter activated

Immediately after the pitch up response, the data showed that the throttle was fully closed, and it was likely that the collective was fully lowered as a simultaneous action as the pilot entered autorotation. In combination, the pitch up and lowering of the collective lever would have caused the rotor rpm to increase rapidly, and to reduce the rpm the pilot would have had to raise the collective. During normal operations, raising the collective would have led the pilot to open the throttle (to maintain rotor rpm), and the data showed that the throttle was opened two seconds after it had been closed. As the rotor rpm was high the engine would have been unloaded and therefore the engine rpm would have risen quickly. This scenario was consistent with the data, which showed the engine limiter operating approximately four seconds after the noise to prevent the engine over-revving.

High rotor rpm

Once established in autorotation, the pilot noted that the rotor rpm was higher than expected for the position of the collective lever. This presented what appeared to him as contradictory and confusing information. The 162F’s collective lever rigging is significantly different to either the R22 or the B206, in that in the fully down position the rotor blade angle is set to negative 2° pitch. During autorotation, there is therefore a correspondingly greater range of movement required to raise the collective lever from the full down position to bring the blades into a positive range of pitch to control rotor rpm. This, and his experience of different types, probably influenced the pilot’s expectation of the required collective lever position to control the rotor rpm.

Landing and ground run

The minor damage to the tail boom skid is likely to have happened during the touch down as the deformation was upwards and aft. This would indicate the helicopter initially touched down in a nose high attitude. The helicopter slid along the field for approximately 10 m until the front left skid caught a rut in the ground. The forward velocity was enough to cause the helicopter to pitch forward and roll over, coming to rest on its left side. As a consequence of the rollover the tail boom struck the ground, and it is likely that this resulted in the structure being destroyed and the simultaneous overload failure of all the tail rotor drive belts. It is also likely that during the rollover the locking barrel of the fuel filler cap became dislodged, allowing fuel to leak from the filler cap as reported by the pilot.

The 162F has a propensity to pitch forward and roll over after an autorotation and in the pilot's manual it states that autorotations should not be practiced to the ground. The later version of the 162F, the Talon, has a stronger landing gear, and skids that are longer and extend further forward to improve landing, with a reduced possibility of causing a roll over.

Conclusion

Small defects in the sealing area of the exhaust valve in cylinder 3 may have allowed a build-up of unburnt fuel in the exhaust system that ignited in flight. The after fire in the exhaust was reported as an "almighty bang" by the pilot and an "explosion" by ground witnesses. In response to several unexpected indications the pilot successfully landed after an autorotation, but the landing ended with the helicopter rolling over due to a landing skid digging into uneven ground.

Published: 7 July 2022.