ACCIDENT

Aircraft Type and Registration:	Hughes 500C-369HS, G-ORRR
No & Type of Engines:	1 Allison 250-C20 turboshaft engine
Year of Manufacture:	1975
Date & Time (UTC):	9 May 2006 at 1306 hrs
Location:	Hanover Hill, Lane End, near High Wycombe, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Helicopter destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	118 hours (of which 18 were on type) Last 90 days - not known Last 28 days - not known
Information Source:	Field Investigation

Synopsis

The pilot reported that as he reduced speed to approach the airfield he experienced erratic power fluctuations. He therefore entered an autorotation and attempted to clear some trees on the approach to his chosen landing site. At about 40 to 50 feet above the ground, the helicopter descended rapidly and as a result landed heavily and rolled on to its side. The pilot was uninjured. The investigation could not identify the cause of the reported power fluctuations.

History of the flight

The pilot reported that he intended to fly from his private site at Checkendon on a short 5 minute flight to Wycombe Air Park where he planned to refuel prior to a further flight He reported that the weather and visibility were good, the wind was 225º/5 kt and the cloud base was 1,800 ft to 2,000 ft.

During the climb out from Checkendon the pilot contacted Benson radar and climbed to 1,200 ft amsl. Just north of Henley he reported that he was visual with Wycombe Air Park and was instructed, by Benson radar, to contact Wycombe. As the helicopter approached the airfield the pilot reduced the engine torque from 50% to 40% and the speed reduced from 95 ft to 80 kt. He made his initial radio call to Wycombe Tower, received the airfield information and set the aerodrome pressure setting on his altimeter subscale.

By this time the helicopter was at about 750 ft over woodlands located about 2.5 miles west of the airfield. The pilot acknowledged a message from Wycombe Tower regarding two other helicopters operating from the airfield, and shortly after this he reported that he was experiencing power fluctuations.

As the engine power started to fluctuate, the nose of the helicopter yawed to the right and then pitched up and yawed to the left. The pilot's perception was that, as he used the collective lever, the engine power reduced to "nothing" and therefore he lowered the collective lever and entered autorotation. He turned 180º back into wind and selected a landing site. At this stage he was at about 450 ft, 60 kt and clear of the woodlands. The pilot reported that as he started to transmit a 'MAYDAY' call the power kicked back in, or the engine reignited itself, and he thought he could salvage the situation. He therefore broke off the radio call and started to raise the collective, but the engine did not respond and both the rotor speed and airspeed started to reduce. By this time the airspeed had reduced to about 30 kt and the helicopter was approximately 100 ft above the ground, with a group of trees to the left of the direction of travel. The pilot said that he pushed forward on the cyclic control in an attempt to recover some airspeed. He raised the nose when the helicopter was 40 to 50 ft above the top of a hill, but at this point it suddenly dropped to the ground.

The helicopter struck the ground on the back of the skids and tail boom. It then pitched forwards and the main rotor blades hit the ground. The helicopter was then violently thrown on to its left side and the main rotor blades detached from the rotor head, which was still turning under engine power. The pilot pulled the fuel cock closed and turned the engine off before vacating the helicopter through the right door.

The pilot reported that all the fuel was in the main fuel tank and the fuel warning light did not illuminate during the flight. He also stated that the start fuel pump remained switched off throughout the flight and that during the power fluctuations his attention was focussed on controlling the aircraft and remaining clear of the trees on the approach to the landing site.

Report by Air Traffic Control

Shortly after the Wycombe controller gave G-ORRR the information for a standard helicopter join he heard the pilot broadcast a 'MAYDAY'. The controller attempted to elicit some more information from the pilot, but received no response. He passed the limited information to the Distress and Diversion Unit at the London Air Traffic Control Centre and at the same time two helicopters operating in the circuit commenced a search for the aircraft. Shortly afterwards the pilot contacted the controller, by telephone, to report that he was uninjured but the helicopter was badly damaged.

The controller reported the weather on the airfield at 1320 hrs as visibility 10 km, wind 350º/5 kt, cloud base 1,600 ft and temperature 17ºC.

Aircraft description

General

The Hughes 500C is a free turbine, turboshaft engine-powered helicopter with a four bladed fully-articulated main rotor and a two bladed semi-rigid tail rotor. The fuselage is a semi-monocoque construction of aluminium alloy. G-ORRR was equipped to carry two pilots in the front and three passengers in the rear. It was fitted with two non-retracting skids and an auto re-ignition system.

Fuel system

The basic fuel system consists of two flexible interconnected fuel cells, located beneath the passenger compartment. It is replenished through a filler neck mounted on the right side of the fuselage. A start fuel pump is mounted in the sump of the left cell and provides fuel through the tank shut-off valve to the engine for starting. Once the engine is started, fuel is drawn from the cells through the shut-off valve by the engine-driven pump. The fuel shut-off valve is located on top of the left fuel cell and is operated by a push-pull cable from a control mounted on the instrument panel. The valve operating lever is detented in the open and closed positions. Fuel tank contents are indicated by a gauge on the instrument panel with a float-operated sender unit located in the left cell. The fuel gauge is marked in 100 lb increments and there is a red dot on the gauge which corresponds to a fuel load of 35 lb. A FUEL LOW yellow caution light, mounted on the top of the instrument panel, illuminates when approximately 35 lb of fuel remains. There is also a warning in the Flight Manual which states that when the caption is illuminated the pilot should avoid large steady sideslip angles and uncoordinated manoeuvres.

G-ORRR was also equipped with a 21 US Gallon (USG) auxiliary fuel tank located behind the rear seat. The auxiliary fuel tank was replenished through its own fuel filler located on the side of the fuselage above the main fuel tank filler. The auxiliary fuel tank did not have a content indication system. It was fed via its own fuel shut-off valve directly into the right fuel cell, and the shut-off valve was located in the pilot's compartment on the floor next to the left door. The Flight Manual Supplement states:

> *'To initiate fuel transfer to the main aircraft fuel tank from the auxiliary fuel tank, push the auxiliary fuel system control knob full down' (Section IV para 4-2);*
>
> *and 'Auxiliary fuel... should transfer in 25 minutes' (Para 4-4).'*

Engine fuel system

The engine fuel control system which was fitted to G-ORRR was manufactured by CEKO, and was of a type which uses fuel as the controlling medium with which to schedule the fuel flow. The main components of the engine fuel system are a high-pressure fuel pump, fuel filter, a Fuel Control Unit (FCU) and a power turbine governor. The FCU controls the engine power by metering the fuel flow up to ground idle conditions; during flight conditions the governor meters the fuel flow so as to control the speed of the power turbine.

Automatic re-ignition system

The engine was equipped with an automatic re-ignition system, which provides an automatic engine restart capability in the event of a flame-out in flight. The system is activated when the gas generator speed (N_1) rpm drops below 50 to 55% or the rotor rpm (N_R) drops below approximately 98%.

The pilot arms the system by moving the selector switch, mounted below the instrument panel, to the ARMED position. An indicator light then illuminates to advise the pilot that the system is armed. If the system has detected that N_1 or N_R has dropped below the trigger limits, the re-ignition circuits are activated. At the same time the RE-IGN caption illuminates. The system does not activate the starter-generator and therefore can not start an engine that has stopped.

Flight Manual

Under the heading PARTIAL POWER LOSS the Flight Manual states:

> '*Under partial power conditions, the engine may operate smoothly with reduced power or it may operate erratically with intermittent surges of power' and 'Turning the start pump ON may smooth out an erratic operating engine and/or restore power enabling the pilot to fly to a favourable landing area. However, do NOT disregard the need to land.'*

The Flight Manual also states that a loss of torque will result in a yaw to the left and a drop in engine and rotor speed, and advises:

> '*.....If possible, fly at reduced power to the nearest safe landing area and land as soon as possible. Be prepared for a complete power loss as any time.'*

Recent maintenance

The helicopter had undergone a 100 hr annual servicing and a 300 hr engine inspection approximately 6 hours prior to the accident. During this maintenance the engine was removed and the compressor casings were replaced.

The pilot reported that there had been no recent faults on the aircraft and that the engine had operated satisfactorily prior to the incident.

Damage to the helicopter

The helicopter and its engine were examined at the AAIB Headquarters at Farnborough on 29 June 2006. The damage was consistent with the helicopter sustaining a heavy landing and then rolling on to its left side. All four main rotor blades were badly distorted and had broken away from the rotor head at approximately 30 cm from the blade attachment point. One blade damper had broken off and both the rotating and non-rotating scissors were fractured. All the damage to the rotor system was consistent with the main rotor turning under power when the blades struck the ground. Both magnetic plugs in the main gear box were clear of debris.

The tail pylon aft of the engine compartment was distorted and the skin was creased. The tail rotor and its drive assembly were relatively intact although distortion of the tail pylon had resulted in the drive shaft tearing through the drive shaft tunnel into the area of the engine air intake.

The glazing on the left side of the helicopter had cracked and there was distortion to the structure around the pilot's door and in the floor frame under the front seats. The skid dampers and main attachment bolts were intact and both skids had broken off near the bottom of the down struts.

Fuel system

During the examination of the fuel system it was noted that the Low Pressure (LP) fuel cock operating cable had pulled out of the fuel cock operating arm, which was still in the fully open position. It was also noted that the LP fuel cock lever mounted on the instrument panel had come out further than normal, which was a possible indication that the cable had pulled off the operating arm. However, in the open position the LP fuel cock sits in a detent and it is considered unlikely that it would have moved out of this position during the accident flight. The pilot subsequently confirmed that the cable had become disconnected after the accident and before the AAIB examination.

The fuel contents of the main fuel tank were established as 100 lb by levelling the aircraft with a plumb line against the aircraft datum point and reading the contents on the fuel gauge. The start pump was also tested and found to have a satisfactory flow rate of 0.125 ltr/sec. Fuel was pumped out of the tank with the start pump in order to check the calibration of the fuel gauge. A total of 85 lb of fuel was pumped out of the aircraft and the low warning light illuminated when the needle was aligned with a red spot corresponding to a fuel load of 35 lb. A sample of fuel was sent for analysis and found to be of a satisfactory standard.

The LP fuel cock was turned on and off several times whilst the fuel was being pumped out of the tank. The flow stopped on each occasion with no evidence of fuel seeping across the fuel valve. Both fuel cells were examined and there was no evidence of any foreign objects in the tank. No fuel was seen to enter the main tank when the valve on the auxiliary tank was opened, which indicated that the auxiliary fuel tank was empty.

A vacuum was applied between the engine inlet pipe and the start fuel pump. This test revealed no evidence of air leaking into the engine fuel system.

Engine

Rolls-Royce accident investigators assisted with the investigation into the possible power fluctuations.

The initial examination revealed that the right rear engine mounting strut had broken during the crash and that a crease in the exhaust duct was probably caused when the aircraft rolled over. The compressor and turbine were free to rotate and all the fuel pipes and control rods were undamaged, correctly fitted and locked. With electrical power switched on, all the engine instruments appeared to operate correctly and the igniter was heard to operate when the auto-ignition was tested. There was no evidence of a fuel leak from any of the pipes on the engine.

Rolls-Royce, under the supervision of the AAIB, undertook a fuel system rigging check and vacuum test in accordance with their procedures detailed in Model 250/T63 Checklist for Accident Investigations, Revised 30 January 2001. The fuel system rigging test established that, prior to the accident, the engine controls were probably correctly rigged and all the parameters were comfortably within the acceptable limits. The vacuum test was satisfactory.

The engine was removed from the aircraft and taken to an overhaul facility were it underwent extensive ground runs. During the pre-run checks it was established that the magnetic plugs, oil filter and fuel filter were clean. The igniter plug was removed and the combustion chamber and turbine were inspected using a borescope; nothing unusual was detected. There was also no evidence of any oil leak from the torque meter which might have given false indications of power fluctuations. The engine was run for just over two hours during the test with no repeat of the fault. Rolls-Royce and the overhaul agency both assessed the engine as being serviceable.

The fuel control unit, governor and High Pressure (HP) fuel pump were removed from the engine and tested independently in accordance with their respective test schedules. All the components were found to be serviceable and the test results were within the acceptable limits. The three components were then subject to a strip examination and their condition was assessed as being typical of components of their age.

It was noted that the governor was, unusually, a 500 series, which is used on the twin engine installation. There are minor differences between the governors used on the single and twin installations, which would not be noticeable to the operator, and the latter is set up to tighter tolerances. As the governor was tested to the twin installation test schedule and found to be satisfactory, it would also have passed the single engine installation test schedule. It is therefore concluded that the use of this governor played no part in this accident.

It was also noted that the speed set diaphragm in the FCU had a kink along its edge, which probably occurred when the unit was assembled. Rolls-Royce reported that any malfunction arising from this would not have been intermittent and would have been detected during initial rig testing.

Comment

Despite an extensive investigation by the AAIB and Rolls-Royce, no fault could be found that would have caused the symptoms described by the pilot. Moreover the fault could not be reproduced when the engine and major components were extensively tested using ground rigs. The helicopter had no recent fault history and no recent maintenance was brought into question.

Whilst the pilot reported that the "engine power reduced to nothing" the damage to the main rotor head indicated that the rotor was still turning under power when the aircraft rolled on to its side. This shows that whilst the engine power might have fluctuated in flight, the engine did not stop. The pilot stated that, during the incident, he concentrated on controlling the helicopter in order to land in a confined site surrounded by trees and did not have the time to select the start pump to ON. Although the Flight Manual states that this is an appropriate action in cases of power loss or fluctuation, with no evidence as to the cause of the reported power fluctuations it is not known if this would have had any effect on the engine performance.