ACCIDENT

Aircraft Type and Registration:	Taylor JT1 Monoplane, G-CEKB
No & Type of Engines:	1 Volkswagen VW 1834 piston engine
Year of Manufacture:	2006
Date & Time (UTC):	27 June 2009 at 1043 hrs
Location:	Great Oakley Airfield, near Harwich, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	1,160 hours (of which 857 were on type) Last 90 days - 12 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft experienced a significant engine problem soon after takeoff. The pilot apparently attempted to fly an abbreviated left-hand circuit at low height to land back at the airfield. During this manoeuvre the aircraft stalled, with insufficient height for the pilot to recover to controlled flight. The pilot was fatally injured in the subsequent ground impact.

History of the flight

The pilot left home at about 0830 hrs on the morning of the accident and travelled to the airfield at Great Oakley, where G-CEKB was kept in a hangar. He had a brief meeting with the airfield owner, during which the pilot appeared to be his normal self. When he left home, the pilot said he had no definite plans to fly. However, at some point he decided he would fly and subsequently 'booked out' for a 1030 hrs flight to Old Buckenham Airfield, about 37 nm north of Great Oakley.

A witness saw part of the pilot's pre-flight external inspection and also heard the engine start, initial taxi out and first part of the takeoff. He later described the engine note as sounding a little rough. The aircraft taxied along the grass taxiway adjacent to Runway 04 and then east along Runway 09 to take off from the start of Runway 27 (Figure 1).

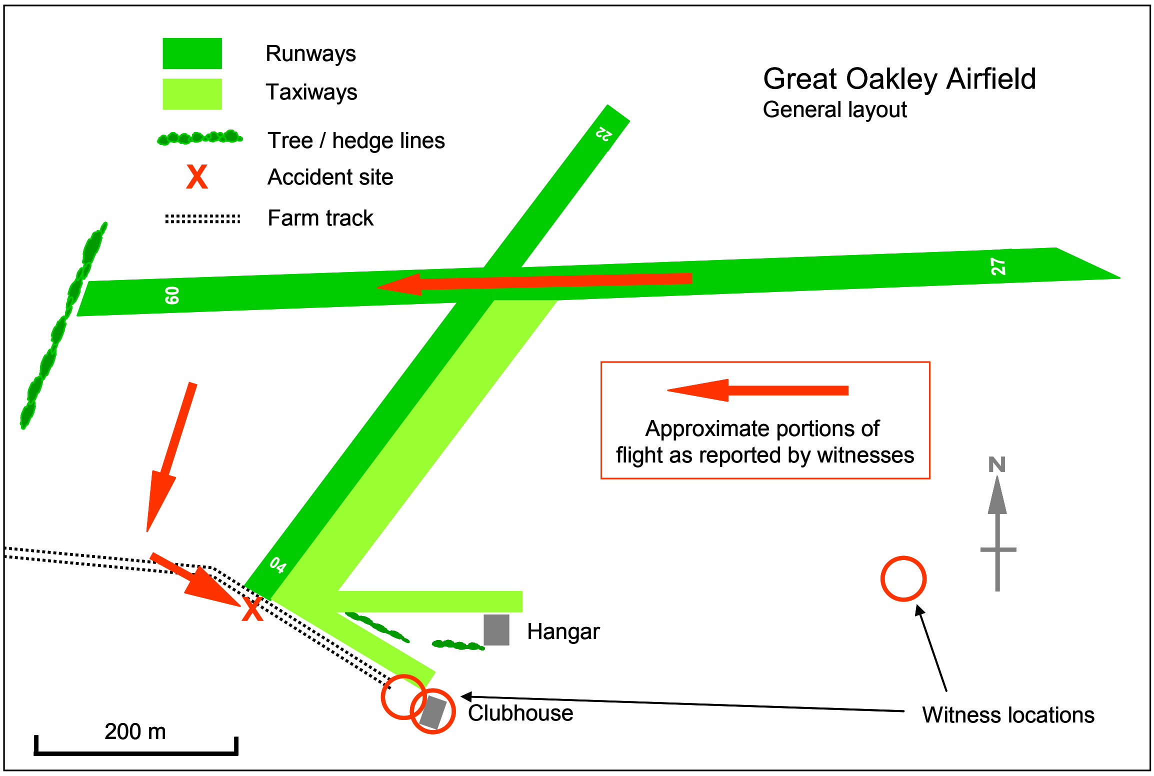

Figure 1

General layout of Great Oakley Airfield.
Portions of the flight seen by witnesses are shown

The aircraft was next seen by a witness adjacent to the airfield, whose attention was drawn to it by the abnormal sound of its engine, which he described as loud and sounding more like that of a tractor than an aircraft. When he first saw the aircraft it was flying about level at an estimated height of 60 or 70 ft, along the line of the runway. It maintained height for a few seconds, but then appeared to begin a descent. At about the same time the sound of the engine stopped, and he assumed the aircraft had landed. The aircraft had been in view for about 6 or 7 seconds.

There was an Air/Ground radio in the clubhouse, and the pilot carried a radio transceiver, but no transmissions from G-CEKB were received. A number of people were in and around the clubhouse; one saw the aircraft flying at an estimated height of 100 to 150 ft in a southerly direction, beyond Runway 04. It then turned left until it was heading directly towards the clubhouse, apparently maintaining height. The witness voiced a concern about the aircraft, which drew others' attention to it. It was then seen to roll briskly to the left to about 45° angle of bank. Immediately afterwards, the aircraft departed from controlled flight, rolled further to the left, adopted a steep nose-down attitude and descended rapidly, impacting the ground shortly before the start of Runway 04.

Most of the witnesses were inside the clubhouse and did not hear the aircraft. An eleven-year-old girl, who was outside the clubhouse and only about 200 m from the accident scene, saw and heard the aircraft as it flew towards her. Initially she thought the aircraft may have been going to land in the same direction (ie on one of the taxiways). She reported hearing the engine making a spluttering sound, causing her to think that there was something wrong. The noise then stopped, and was replaced with a whistling noise, just before the aircraft rolled to the left and descended rapidly.

Onlookers rushed to the scene to assist the pilot, but there were no signs of life. Emergency services, including an air ambulance, attended, but it was confirmed that he had sustained fatal injuries.

Recorded information

The pilot's Garmin GPS 89 satellite navigation unit was recovered from the wreckage. It had recorded a total of twelve tracks made by the pilot in the preceding three months, including the accident flight. Altitude information is not recorded on this model of GPS unit.

The track of the accident flight is shown at Figure 2. The recording starts at 10:37:20 hrs as the aircraft was taxiing prior to takeoff and ends at 10:42:43 hrs, near the accident site. The track shows that the aircraft entered Runway 09 and taxied part-way along it, before stopping for approximately one minute, presumably while the pilot carried out his before takeoff checks (position A of Figure 2). The aircraft then continued taxiing to the takeoff point. The average groundspeed between each GPS track point is presented in Figure 3.

Figure 2

GPS track of the accident flight.

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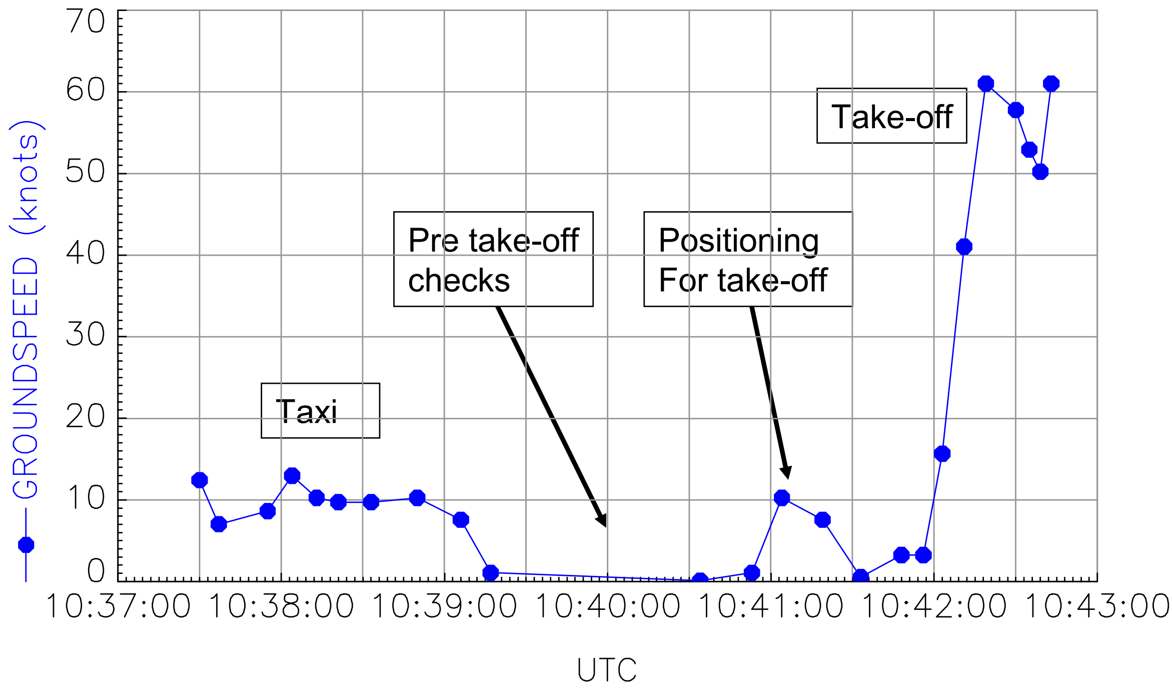

Figure 3

Accident flight calculated groundspeeds

Accident site and aircraft wreckage

The aircraft impacted the ground in a field of standing crops, just outside the airfield boundary. The ground track at impact was 065º(M). The ground marks were indicative of a near-vertical impact angle. Remains of the wooden propeller blades were driven a short depth into the ground at the centre of the ground mark.

The engine, instrument panel and fuel tank had separated from the fuselage. The engine block was relatively intact, though one of the rocker covers had detached in the impact and one of the engine intake manifolds had broken off at the point where it entered the cylinder head. Although the fuel tank was heavily disrupted, it still contained a significant quantity of fuel, which was noticeably green in colour rather than the normal blue of Avgas.

The fuselage came to rest on the edge of the airfield, having travelled forward and left from the initial point of impact and rotated 45° clockwise. The left wing was more heavily damaged than the right. The flying control surfaces were intact and still connected to the cockpit controls, with the exception of the aileron control rod connection to the bellcrank, which had failed on both wings.

Airfield information

Great Oakley is an unlicensed airfield, 3.5 nm south-west of Harwich. It has two grass runways, designated 04/22 (600 m long) and 09/27 (850 m long). The airfield is situated amongst gently undulating terrain and is surrounded by fields. At the time of the accident, these contained standing crops.

The surface of Runway 09/27 has a notable downslope 70 m from each end. Pilots are advised to treat these as overrun areas only. When taking off from the highest elevation, close to the Runway 27 numbers, the runway slopes noticeably downwards in the first and last thirds, with a more level section in the vicinity of the crossing runway. The downslope in the last part of Runway 27 ends at a substantial hedge line on the airfield boundary. The Runway 27 circuit is right-hand.

Pilot information

The pilot, who had a background as an aircraft technician, had flown regularly since gaining his Private Pilot's Licence in 1976. He held a valid Class 2 medical certificate. G-CEKB was the second Taylor Monoplane he had built; the first was completed in 1986, since when he had flown the type almost exclusively. He subsequently built G-CEKB, and first flew it in September 2008.

Witnesses interviewed at the flying club spoke highly of the pilot and reported that he was very conscientious with regard to operating and maintaining both his aircraft. They described him as having a conservative approach and being highly knowledgeable and experienced with regard to the Taylor Monoplane aircraft type. Members of the pilot's family said that he had devoted a significant amount of time and resources into building and maintaining the aircraft.

Pathology

A postmortem examination on the pilot revealed no underlying medical issues which could have caused, or contributed to, the accident.

Meteorological information

The airfield owner maintained a meteorological observation station. Data recorded by the station showed that, at the time of the accident, the temperature was 21ºC, with a relative humidity of 77%. The surface wind was west or north-westerly at about 3 to 5 kt. Based on the weather reports from airports at Stansted, Southend and Norwich, the visibility would probably have been about 10 km, with no significant cloud.

Aircraft information

General description

The prototype Taylor Monoplane first flew in 1959. It is a homebuilt, single-seat, Permit-to-Fly aircraft constructed from wood and fabric. It is equipped with a tailwheel landing gear. It is not equipped with wing flaps. The accident aircraft was fitted with a fixed-pitch propeller driven directly by an 1834 cc aero-converted Volkswagen (VW) engine which required Avgas 100LL fuel. As the aircraft had no electrical system, the engine was started by hand swinging the propeller.

G-CEKB history

The aircraft was built by the pilot over a period of some eleven years using a set of technical drawings and informal guidance from various sources. He had previously built another Taylor Monoplane, and had introduced various upgrades on the later aircraft, including a more powerful engine. The engine was modified from a standard 1600 cc VW automotive engine by increasing its capacity to 1834 cc and fitting a dual ignition system and oil cooler. The engine components were modified or supplied by a specialist supplier, but the pilot had assembled the engine himself.

Based on accounts from various witnesses, G-CEKB appeared to have suffered from engine-related problems dating back almost to its first flight in September 2008. It is believed that the pilot had performed a number of troubleshooting activities on the aircraft as a consequence, but he reportedly completed most of work on the aircraft himself, without assistance. Witnesses were not able to provide detailed accounts of the problems or first-hand knowledge of the rectification work carried out.

Some witnesses recalled issues concerning engine starting problems when the engine was warm and of the engine running rough, along with limited reports of an in-flight engine problem. There was also a report that the pilot had identified a large rpm drop when carrying out magneto checks. He had made a single entry in the engine logbook, dated 15 June 2009, highlighting the starting problems on the engine. It identified that he had removed both magnetos from the aircraft and disassembled them. The specialist spares supplier used by the pilot stated that he had exchanged the coils given to him by the pilot for newly overhauled ones. The pilot had reassembled the magnetos with new contacts and condensers and refitted them to the aircraft. He had also installed new spark plugs.

The same logbook entry, dated 15 June 2009, identified that the pilot had also adjusted the tappets. Some witnesses reported that he had fitted home-made shims to the rocker arm assemblies to increase the tappet clearances, after experiencing difficulty achieving the correct clearances. Additional reports suggested that the pilot had identified a concern regarding the security of the rocker arms on all four cylinder heads after finding them loose whilst investigating an engine problem. This was apparently addressed by applying 'Loctite' adhesive to the securing nuts. One witness reported that, in the days immediately prior to the accident, the pilot had determined that two of the engine's four cylinders were running cold. It is believed the pilot had attempted to rectify these various problems in the six weeks leading up to the accident. Much of this evidence was supported by findings from the wreckage examination, but as the pilot did not keep detailed maintenance records, an exact timeline of the specific problems and the resulting maintenance actions could not be fully determined.

The Light Aircraft Association (LAA) inspector who routinely inspected the aircraft and had a long-term association with the pilot, reported that he had arranged to assist the pilot in troubleshooting the engine issues, and to inspect the workmanship and conformity of any modifications, during the afternoon of the day of the accident. He was therefore surprised to discover that the pilot had flown the aircraft that morning.

Aircraft's stalling characteristics

On 18 September 2008, the pilot conducted a flight test in G-CEKB as part of the process of qualifying the aircraft for issue of a Permit to Fly. The flight test schedule required examination of the aircraft's stalling characteristics. The pilot recorded on the flight test form that the aircraft exhibited *'slight buffet'*, approximately 3 kt above the actual stall speed.

Other Monoplane owners and pilots familiar with the aircraft type explained that the aircraft is normally operated at speeds considerably above its stall speed because, with its relatively low inertia, it can lose airspeed relatively easily. They described how considerable power is required to maintain speed in a turn, adding that level turns with bank angles approaching 45º cannot be maintained without a loss of airspeed.

The aircraft's wing design does not incorporate 'washout', a feature which reduces local angles of attack at the wingtips and encourages inboard sections of the wing to stall before the outboard sections. This normally desirable design feature aids stall warning and helps prevent uncontrollable rolling moments caused by one wingtip stalling before the other, as well as helping to ensure aileron effectiveness at low airspeeds.

Engineering investigation

Fuel system

Although fuel was present in the tank, there was no fuel in the line to the engine, or in the carburettor bowl. Detailed inspection of the fuel pipe routing identified a significant restriction in the rubber hose caused by a clipping point, with an associated fracture in the hose; both were confirmed to be impact damage. The post-accident orientation of the engine would have allowed fuel to drain from the pipe out of the fracture. No other restrictions were found in the fuel system. The fuel pump had broken off in the impact, but its engine-driven shaft operated freely. The fuel pump contained residual fuel and showed no defects. The carburettor appeared to be serviceable. The aircraft was not fitted with an auxiliary fuel pump.

The fuel pump and carburettor were mounted on the top of the engine; this resulted in the fuel supply line from the tank following a 'U'-shaped profile with a number of turns to allow it to be secured to the engine block. There was no heat shielding fitted to the rubber pipe where it was routed alongside the engine and there were numerous diameter changes for in-line components such as the fuel filter and non-return valve. The flexible pipes used in the aircraft's fuel system were the correct specification for use with gasoline.

Fuel sample

The fuel sample recovered from the wreckage was laboratory tested against the specification for Avgas 100LL. It did not meet the requirements for appearance, vapour pressure, distillation, gum and lead content. The colour differed from the bright blue of Avgas 100LL and the high gum content suggested that the fuel may have been contaminated. Further analysis of the fuel and the gum residue showed the presence of higher boiling point components not consistent with Avgas 100LL. Comparison with a sample of unleaded motor gasoline (Mogas) indicated that some of these components may have come from the presence of Mogas. The presence of phthalate was also indicated in the gum residue. The presence of phthalate in fuel can be an indication that the fuel has been in contact with an elastomeric material, possibly during storage, and has leached out some of the plasticiser. It was not possible to confirm the source of the plasticiser.

Engine examination

A detailed strip of the engine was carried out which identified no mechanical failures, other than to the pushrods and rocker arm assemblies which had been distorted by the impact. This prevented any accurate assessment of tappet clearances. The rocker arms were fitted with unusual[1] rotating ball bearing tappet screws. These were identified as a performance tuning part supplied with the engine when it was purchased from the specialist supplier. The balls had flats which contacted the top of the valve when correctly orientated. However, it was noted that the ball could rotate changing the clearance and making it difficult to measure accurately. The fittings containing the balls could also be adjusted on a thread to change the gap. They had all been adjusted to the highest position to give maximum clearance. The home-made shims fitted by the pilot were present and the rocker arm retaining nuts were still secure and in place. Also of note was the fact that dirt was compacted by the piston into one of the cylinder heads fed by the fractured intake manifold. A piece of wood and fabric from the engine cowl had worked itself between one of the rocker arms and the top of the valve spring, on the side of the engine where

Footnote

1 The engine strip was conducted with the assistance of an engineer with broad experience of VW aero engines, who commented that he had not seen this kind of tappet arrangement used previously.

the rocker cover had been dislodged in the impact. The propeller hub also displayed circumferential scratch marks on its front face.

Ignition system

The aircraft was not fitted with an electrical power system; engine ignition was provided by a simple circuit consisting of a pair of chain-driven magnetos energising a dual high-tension lead and spark plug system. Neither magneto was fitted with an impulse coupling. The engine drive chain was intact and properly tensioned. The ignition leads were intact, with no continuity problems, though the distributor cap on each magneto had been shattered in the impact. The spark plugs were new and in good condition, but the electrode gaps on all eight spark plugs were exceptionally small and well below the normal range of 0.016 to 0.022 inch. The magnetos were removed, inspected and tested. The left magneto was correctly set up and produced a good spark. However, the right magneto's rotor cog, cam and points were set up such that it produced a weak spark at the wrong time. Misalignment of the rotor cog may have been caused by the impact, but even if this had been correctly set previously, it is likely that the magneto was not producing a strong spark before the accident.

Other information

Vapour lock

The LAA publish advice regarding 'vapour lock' in an engineering information leaflet on the use of unleaded Mogas in light aircraft.

Vapour lock is caused by vaporised fuel collecting and forming a 'bubble' which becomes trapped at a high point or constriction in a fuel pipe, preventing the passage of fuel to an engine causing it to cut out (or prevent it from being started). However, fuel can also vaporise at a localised hot spot or low pressure area in the fuel system without becoming trapped; a stream of vapour bubbles will then enter the carburettor along with the fuel, causing lean running and reduced power. If this form of fuel vaporisation is encountered, retarding the throttle can result in the reduced airflow into the engine giving a better fuel/air mixture for combustion, thus removing the symptoms of the problem. However, as the problem is exacerbated by an increasing engine temperature, the symptoms are likely to return as soon as an increased throttle setting is re-selected.

Vapour lock is most likely to occur in aircraft equipped with engine-driven mechanical fuel pumps and which do not have an additional fuel boost pump. If the engine-driven fuel pump is located (or as a consequence of aircraft attitude becomes situated) above the level of fuel in the fuel tank, the fuel pressure on the upstream side of the fuel pump is reduced below atmospheric pressure by the action of the pump 'sucking' the fuel, increasing the likelihood of fuel vapour forming on the inlet side of the pump. This problem is exacerbated by heating of the fuel within the supply pipe, particularly where unshielded pipes come into contact with the engine. The cylinder heads on this engine typically run at 140°C and can reach 180°C on a hot day. This can create significant residual heat build-up under the engine cowling when there is limited cooling airflow over the engine.

Engine failure after takeoff

An engine failure soon after takeoff requires a pilot to take effective action quickly. A safe airspeed must be maintained and a suitable landing area chosen. If insufficient runway length remains, an area beyond the runway must be chosen for a forced landing. Turning at low altitude following a complete or partial engine failure is extremely hazardous as the aircraft is at considerable risk of stalling whilst manoeuvring, so the area chosen must normally be within about 30º of the takeoff direction.

A pilot faced with a rough running engine after takeoff, or one producing insufficient power to climb safely, must decide quickly whether the best course of action is to land ahead, or to attempt to land back on the airfield. Although the best advice is generally to plan for the worst case and land ahead, in reality several factors may be involved. As well as the perceived seriousness of the problem, there may be a shortage of available forced landing areas, the considerable probability of damage to the aircraft and the pilot's proficiency or confidence to commit to an immediate forced landing.

The following advice to General Aviation pilots is given by the CAA in its publications *Safety Sense Leaflet 1a: Good Airmanship* and *General Aviation Safety Information Leaflet (GASIL) 1 of 2006*:

> *'In the event of engine failure after take-off, if the runway remaining is long enough, re-land and if not, never attempt to turn back. Use areas ahead of you and go for the best site. It is a question of knowing your aircraft, your level of experience and practice and working out beforehand your best option at the aerodrome in use.'*

> *'It is possible that in certain circumstances turning back to the aerodrome might be the option which minimises the risk of injury to the aircraft occupants, provided the pilot maintains a safe airspeed and sufficient height exists taking into account the extra drag from a windmilling propeller. However, in general, landing ahead is nearly always going to be the safest option in the event of an engine failure.'*

Analysis

General

There was no evidence to suggest that a pilot health issue may have contributed to the accident, and the flying weather was good.

Aircraft handling issues

The flightpath after takeoff was not consistent with the pilot's declared intentions, nor with local flying procedures. Had the pilot intended to return to land for any reason other than a very serious one, he probably would have flown a normal circuit to the north, back to Runway 27 or possibly Runway 22. The circumstances of this accident indicate that an unplanned event forced the pilot to change his intentions soon after takeoff, and that he was probably attempting to make an immediate landing back on the airfield. In the course of manoeuvring to land, he lost control of the aircraft and had insufficient height in which to recover.

The GPS groundspeed indicated apparently normal takeoff acceleration until the aircraft would have been approximately over the midpoint of the runway. However, the speed did not continue to increase but reduced instead as the aircraft turned crosswind.

The only witness who saw the aircraft immediately after takeoff thought the engine noise was abnormal. He described the aircraft starting a descent after the midpoint of the runway, accompanied by a reduction in engine sound. This may have been a feature of perspective and shielding, but if it occurred, one possible explanation is that the pilot decided to land ahead on the runway remaining, and the cessation of engine noise was a result of the pilot closing the throttle. However, the aircraft did not land ahead. This could have been due to the unfavourable runway slope and the unforgiving overrun area, or the engine power may have partially recovered. Whatever the reason, the engine must have been running and capable of producing some power for the aircraft to climb again, or at least maintain height. Sufficient power was also available for the pilot to initiate a turn to the left, albeit at a very low height.

The pilot's intentions are not known. He may have been positioning for a landing on Runway 04, on one of the taxiways or one of the many fields surrounding the airfield. Evidence from witness and GPS data, however, do show that that the pilot flew a tight pattern, at low height placing the aircraft relatively close to the Runway 04 threshold. A landing on one of the taxiways may have been possible from this position, or the pilot may have decided to try to land on the runway. Had he chosen to do the latter, it would have required a relatively late and tight left turn.

The safety message clearly stated in the CAA publications is that an attempt to turn back to the airfield from a low height following an engine failure has an associated high risk. Numerous accidents have resulted from pilots attempting to turn too tightly and/or allowing the airspeed to decay in an attempted turnback, with the inevitable result of a stall and then loss of control, with often fatal consequences.

Technical issues

The final position of the fuselage relative to the ground marks and the damage to the left wing are consistent with rotation of the aircraft following a left wing stall. The investigation confirmed that all damage to the aircraft structure and flying controls was a consequence of the ground impact.

A number of the engine problems mentioned by witnesses could be explained by features of the engine and its installation, as identified during the investigation.

The fuel system installation used on the accident aircraft would have made it more vulnerable to fuel vaporisation issues, as would the addition of Mogas into the fuel. The hot starting issues reported may, therefore, have been symptomatic of fuel vaporisation problems. The fuel system installation and use of Mogas may also have induced fuel vaporisation which caused or contributed to rough running of the engine during the accident flight. The first Monoplane built by the pilot had a different engine installation with the carburettor on the bottom of the engine, a gravity-fed fuel system and a fuel pipe routing which did not bring it into contact with the engine block. It was therefore less susceptible to fuel vaporisation and the pilot may not have encountered the symptoms prior to flying the new aircraft.

The flexible pipes used in the aircraft's fuel system were the correct specification for use with gasoline. It is therefore likely that the plasticiser contamination occurred while the fuel was in storage. Although it highlights the significance of using approved storage containers, plasticiser contamination is not considered to have contributed to the engine problems during the accident flight, as no gum deposits were found within the engine fuel system accessories which are sensitive to this issue. This was also consistent with the low operating hours of the engine.

The difficulty experienced by the pilot in achieving the correct tappet clearances may have been exacerbated by the unusual rocker arm arrangement. He had attempted to address the issue by fitting home-made shims, but this reduced the thread exposed to secure the retaining nuts for the rocker arms. This may in turn explain why he had to apply 'Loctite' to the nuts to prevent them from working loose. It was not possible to determine whether this solution had fully addressed the original concerns that initially prompted the pilot to adjust the tappets.

It is possible that the spark plug gaps were reduced by the pilot to compensate for the weak spark produced by the right magneto. The issues identified with both the spark plugs and the magneto may have had a detrimental effect on the performance of the engine.

The evidence of the dirt in the cylinder, the wood and fabric under the rocker arm and the scratches on the propeller hub indicate that the engine was still running at the point of impact.

Whilst the exact nature of the problem that became manifest during the takeoff and its cause could not be confirmed, the engine issues identified could, either alone or in combination, have resulted in power loss or rough running.

Defect troubleshooting

The pilot had taken considerable efforts to address the engine problems on his aircraft, but had not kept a comprehensive record of the work carried out. By working alone and not keeping a full record of the work completed, the task of troubleshooting defects in a logical manner over an extended period of time became more difficult, and this may have prevented the LAA inspector from being able to assist him effectively or to identify problems such as the incorrectly set up magneto.

LAA inspectors have experience and expertise which can be drawn upon by members when maintenance work is being carried out or certified. In order to benefit fully from this resource it is essential to record the work done and ensure that it is approved, where necessary, before further flight. The LAA has a downloadable template of a maintenance staging sheet for this purpose on their website.

Conclusion

The investigation concluded that the aircraft developed an engine problem almost immediately after takeoff, although the exact nature of the problem could not be positively determined. The pilot appears to have attempted to make an abbreviated left hand circuit at a low height, to land back on the airfield. During this manoeuvre, he lost control of the aircraft. It stalled and departed from controlled flight, with insufficient height available for the pilot to recover.