ACCIDENT

Aircraft Type and Registration:	Beech 90, N46BM
No & Type of Engines:	2 Pratt &Whitney PT6A-28 turboprop engines
Year of Manufacture:	1978
Date & Time (UTC):	18 May 2011 at 1131 hrs
Location:	Kinson Manor Farm, Bournemouth
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Substantial damage to airframe and powerplants; landing gear collapsed
Commander's Licence:	FAA Commercial Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	800 hours (of which 660 hours were on type) Last 90 days - 13 hours Last 28 days - 6 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft's climb rate was lower than expected after takeoff and it was subsequently unable to maintain altitude. The pilot made a forced landing into a field. The cause of the apparent power loss was not determined.

History of the flight

The pilot had planned to fly from Bournemouth Airport to Manchester Airport operating the flight as a single pilot, with a passenger seated in the co-pilot's seat. He arrived at the airport approximately one hour before the planned departure time of 1130 hrs, completed his pre-flight activities and went to the aircraft at approximately 1110 hrs. The 1120 hrs ATIS gave the weather at the airport as: surface wind from 230° at 10 kt, visibility 10 km or greater, few clouds at 1,000 ft, broken cloud at 1,200 ft and at 2,000 ft, temperature 16°C, dew point 12°C and QNH 1015 hPa.

After starting the engines, the pilot was cleared to taxi to holding point 'N' for a departure from Runway 26 and he was given clearance to take off at 1127 hrs. At 1129:45 hrs, approximately 55 seconds after the aircraft became airborne, the aerodrome controller transmitted "FOUR SIX BRAVO MIKE DO YOU HAVE A PROBLEM?" because he believed the aircraft was not climbing normally. The pilot replied "NOVEMBER FOUR SIX BRAVO GOING AROUND" and, shortly afterwards, "FOUR SIX BRAVO REQUESTING IMMEDIATE RETURN". The controller cleared the pilot to use either runway to land back at the airport but received no reply.

The pilot carried out a forced landing into a field 1.7 nm west of the Runway 08 threshold at Bournemouth Airport and neither he nor his passenger was hurt.

Information from the pilot

The pilot reported that both engines started normally and the propeller checks that he carried out at the holding point before takeoff were satisfactory (see the section 'Propeller checks' below). He was given takeoff clearance while lining up on the runway and did not bring the aircraft to a halt before applying power.

The pilot believed that, if he selected the propeller levers fully forward (high rpm) and then moved the power levers forward to the torque limit[1], the propellers would exceed the 2,200 rpm limit during the takeoff run. Consequently, he normally took off with the propeller levers approximately half an inch aft of the fully forward position. He used this takeoff technique on the accident flight and recalled that the takeoff seemed normal with no tendency for the aircraft to drift either left or right. There was little crosswind and so he held the ailerons neutral during the takeoff roll and rotated the aircraft at an indicated airspeed of 104 kt. Immediately after leaving the ground, the pilot "dabbed" the brakes and selected the landing gear to UP. Shortly afterwards he noticed that the aircraft had drifted slightly to the left of the runway centreline, although he had not felt a marked swing that would have accompanied an engine failure. He also recalled that the aircraft's heading was still very close to the runway heading. After raising the landing gear, he put his hand back on to the power levers and noticed that the left lever was approximately "half an inch" behind the right lever. He rebalanced the left lever and thought that the imbalance might have caused the aircraft to drift left.

The pilot sensed that the aircraft's rate of climb was not normal although he did not recall the actual rate of climb. He checked the primary engine indications[2] and stated that they "seemed normal". No right rudder was required to keep the aircraft balanced and the pilot did not believe that the left engine had failed. He confirmed that the landing gear and flap were retracted (the takeoff had been made without flap), pushed the power levers forward to increase power and moved the propeller levers aft slightly, believing this would prevent the propellers from exceeding 2,200 rpm.

The aircraft was climbing "but not well" and the pilot asked the controller whether he could return to the airport. He began a right turn intending to fly a circuit to the right and land back on Runway 26. The engine instruments still seemed to the pilot to be indicating normally, and the master warning system generated no warnings or cautions, but he had to lower the nose to maintain the speed above 88 kt, which was the Minimum Single Engine Control speed, V_{MCA}. Shortly afterwards, the pilot realised that the aircraft was no longer climbing and decided to turn left to position for a return to Runway 08. As he began the turn, the EGPWS generated a SINK RATE warning indicating that the aircraft was descending. The pilot levelled the wings and, realising that the aircraft was still descending, decided to land in a field ahead.

The pilot selected the landing gear DOWN as the aircraft neared the field and moved the power levers to idle as the aircraft clipped some trees at the field boundary.

Footnote

[1] The torque limit the pilot used was marked by a solid red line on the torque gauge. See the later section on engine power.

Footnote

[2] Torque, rpm, and Interstage Turbine Temperature (ITT).

After the aircraft came to a halt, he turned off the fuel and master switches and vacated the aircraft. Neither he nor the passenger was injured.

The pilot stressed that his operating technique on this takeoff was no different than on any other. He could not understand at the time, or subsequently, why the aircraft had performed so differently on this occasion.

Accident site details

The aircraft landed in a large field approximately two miles west of Bournemouth Airport, having flown through some young trees on the southern bank of the River Stour at a height of approximately 10 ft and on a track of around 207º(M). It touched down heavily on all three landing gears in a slightly nose-down attitude. The nose leg detached and was found approximately 50 m from the trees together with additional small items of debris, mainly from the underside of the engine nacelles. Between approximately 90 and 100 m from the trees, coincident with a shallow dip in the surface of the field, ground marks suggested that the aircraft became airborne momentarily. Subsequently, the main landing gear collapsed/retracted and the aircraft slid along on its belly, rotated to the left and came to a halt approximately 180 m from the trees on a heading of 112º(M).

The aircraft remained intact through the impact sequence although the main spar outboard of the left engine broke at some point. There was some creasing in the rear fuselage and there were numerous areas of damage on the leading edges of the wing and horizontal stabiliser caused by contact with the trees. The radome suffered significant damage and the radar antenna dish became detached. There was no fire.

Propeller ground marks

There was a short sequence of propeller blade 'chop marks' in the area of the initial touchdown point. The marks reflected the slight nose-down attitude at impact, which was probably accompanied by significant airframe and landing gear deflections. The distances between successive marks were approximately 60 cm and 56 cm for the left and right propellers respectively. When the memory module in the Honeywell EGPWS was downloaded subsequently (see 'Recorded information' below), the data indicated that the groundspeed at landing was approximately 88 kt. This, in conjunction with the blade mark spacing, gave values of 1,590 and 1,625 rpm respectively for the left and right propellers at impact.

On-site investigation

Examination of the cockpit showed that the pilot had returned the engine controls and switch selections to their normal shut-down positions, although the landing gear selector was found in the UP position. The pilot stated subsequently that he had not raised the lever during the accident sequence and suggested that the passenger might accidentally have knocked it to this position as he left his seat.

The left and right propeller blades displayed a symmetrical degree of damage and the pitch changing mechanism in both hubs failed during the accident sequence. The right propeller piston, mounted on the front of the hub, had broken off and was retained only by the feathering spring and Beta rods.

The aircraft was lifted off the ground in order to obtain fuel samples from the tank drains and from as close to the engines as possible. As it was raised, fuel was seen leaking from beneath both engines from fractured fuel delivery lines. The fuel had clearly been leaking for some time and, while some samples were collected, they were probably not representative of the fuel the engines were using at the time of the accident[3].

There were three fuel tanks in each wing: inner, outer and nacelle. The filler caps were examined for fit and seal condition and found to be satisfactory, which indicated that there was no scope for ingress of significant amounts of water as a result of being parked in heavy rain. A subsequent test revealed that seals on the inner tab mechanisms were in similarly good condition.

Following the on-site examination of the aircraft, the engines were removed for subsequent strip examination under AAIB supervision at an overhaul agent for the engine type.

Examination of the engines

The Pratt & Whitney PT6A-28 is a turbine engine driving a propeller shaft via a two-stage reduction gearbox. There are two major rotating assemblies; one of them being the compressor and its associated turbine, which together comprise the 'gas generator'. The final stage of the compressor is a centrifugal impeller, the outlet scroll of which delivers compressed air into the combustion chamber. The other rotating assembly is the 'free turbine', which consists of a single turbine stage located immediately downstream of, but not connected to, the compressor turbine and which drives the input shaft of the reduction gearbox.

Engine accessories include the primary propeller governor and a fuel control unit (FCU) that meters fuel in response to the power demand on the engine.

Left engine

The engine was fitted to N46BM in December 2007 following overhaul at which point it had achieved 15,243 hours and 10,637 cycles since new. The engine logbook did not record the hours and cycles since overhaul and did not record anything after November 2010. However, the evidence available indicated that, at the time of the accident, the hours and cycles since overhaul were in excess of 320 and 200 respectively.

The intake support struts around the intake annulus were broken, probably as a result of inertial loads experienced at the initial touchdown. This resulted in the gas generator module losing its location because the bearing at the impeller end of the compressor is located in this area. Disassembly of the engine showed that this lack of location had allowed the impeller to contact the shroud because all the blades exhibited significant burrs and the shroud surface had had much of its protective coating abraded away.

In this engine type, the gas flow downstream of the combustion chamber is turned through 180º in the 'large exit duct'. The surface of this duct exhibited some 'speckling', which had the appearance of solidified globules of the coating material from the impeller shroud. Such evidence is usually indicative of small pieces of material, in this case particles of the impeller shroud coating, being melted on passing through the combustion chamber and resolidifying on the exhaust or other engine components. It therefore provides an indication that the engine was alight at the moment of a severe impact.

Disassembly of the engine showed that the reduction gear system functioned smoothly and the gearbox magnetic chip detector was clean. Other components in the rotating assemblies, such as the compressor turbine

Footnote

3 During the subsequent site clearance it was found that fuel had penetrated approximately 1 m into the ground.

blades, were generally in a condition consistent with being part way through their overhaul lives. The tips of the power turbine blades had rubbed against the shrouds over part of the circumference as a result of distortion of the casing. After removal of the power turbine, some burnt fragments of grass were apparent in the casing near the combustion liner.

Elsewhere in the engine, the fuel nozzles were normal in appearance and the No 1 bearing, at the inlet end of the compressor, was in good condition.

In summary, no significant defects were found within the engine that might have been present before the accident.

Right engine

No significant maintenance had been carried out on the engine since an inspection and repair of the hot section in May 2005, at which point the engine had achieved 12,424 hours and 8,186 cycles since new. As with the left engine, the engine logbook recorded no flights after November 2010, although the evidence available indicated that in excess of 1,500 hours and 1,200 cycles had been achieved since the hot section repair. The hot section was reinstalled on the aircraft by a different maintenance organisation from the one which installed the left engine following overhaul.

A significant quantity of grass had adhered to the outside of the engine intake screen, indicating that the compressor was still rotating at speed when the aircraft was sliding across the field (the grass had entered through the air intake on the underside of the nacelle). The lack of grass on the left engine was probably indicative of the fact that the compressor on the latter spooled down rapidly following the failure of the intake struts.

Disassembly of the compressor revealed that the components were in good condition, with no evidence of rubbing. The combustion chamber liner was in a similar condition to that of the left engine, with areas covered with carbon deposits. However, there was no evidence of molten metal deposition in the large exit duct.

The reduction gears were smooth in operation and the associated magnetic plug was free from debris. There were fragments of scorched grass in the combustor outer casing, which were less burnt than those found in the left engine. This might indicate faster cooling of the casing due to the undamaged compressor taking longer to spool down.

Examination of all the remaining components, such as the fuel nozzles, revealed no significant defects and it was concluded that the engine was in a serviceable condition at the time of the accident.

Engine accessories

The engine accessories tested comprised the compressor bleed valves, FCUs, engine-driven pumps and the start flow valves.

The compressor bleed valve on each engine opens to spill excess compressor air overboard at low power and closes progressively as the power demand on the engine increases. The rolling diaphragms in both engine compressor valves were intact and the valve movements were smooth in operation. When bench tested, it was found that the control pressure for the unit from the left engine was slightly below the value specified in the component Maintenance Manual. The overhaul company commented that this would have resulted in the valve closing at a slightly higher engine rpm than normal, but that it would have had no noticeable effect on its operation.

The FCUs were bench tested, with the results being typical of units returned from the field; it was concluded that they would have operated satisfactorily. An inspection of some of the internal chambers revealed no evidence of microbiological compounds or any other debris.

The start flow valves, which should have no effect on engine operation after start, were found to operate satisfactorily apart from slightly stiff operating shafts, which were attributed to typical in-service wear. The engine-driven pumps, located upstream of the FCUs and designed to produce an rpm-dependent fuel pressure, were found to operate satisfactorily.

It was considered possible that identically mis-rigged propeller governors or badly calibrated tachometers may have caused the engines to operate at below normal rpm thereby resulting in a loss in performance on both powerplants. However, the technical records indicated that relevant engine maintenance activity, including rigging of the governors, was conducted by different organisations at different times; thus these potential causes of low rpm were thought to be highly improbable.

Fuel

It was not possible to obtain an airframe fuel sample that was representative of fuel being used by the engines at the time of the accident. The samples that were taken contained no visible water or evidence of microbiological compounds such as algae, and complied with the Jet A1 specification. Tests on fuel found in the fuel filter bowls of the FCUs of both engines produced similar results. The dissolved water content of all the samples was between 65 and 75 ppm (parts per million) and the fuel analysts commented that levels below 150 ppm do not generally give cause for concern. The left airframe fuel filter was found to be clean (the unit on the right side was damaged) and the FCU filters were also clear, as were the inlet screens of the engine driven pumps.

It seemed likely that, if water was present in the fuel in significant quantities, it would have resulted in abnormal engine operation before takeoff and asymmetric power fluctuations during takeoff. Although no such symptoms were reported by the pilot, the possibility that the fuel was contaminated by water was considered. Earlier in this report, it was concluded that water would not have entered the tanks as a result of the aircraft encountering rain, which left the bowser as the only potential source of contamination. As there were no reports of any other aircraft being affected, it was concluded that the fuel was not contaminated.

Recorded information

Recorded information was available from the Bournemouth Airport radar and the aircraft EGPWS computer[4]. The aircraft position and Mode C altitude was recorded approximately once every four seconds by the radar. The record commenced as the aircraft positioned for takeoff and ended approximately 10 seconds before the aircraft landed in the field. When the EGPWS computer generates a warning, it also records a 30 second snapshot[5] of parametric information, which includes GPS position, groundspeed and derived altitude. During the flight, two warnings were generated by the EGPWS. The first was a sink rate warning, which occurred shortly after takeoff, and the second was a terrain warning, which occurred shortly before the aircraft touched down. When the radar and EGPWS records were combined, a complete record of the accident flight was available (Figure 1 and Figure 2).

Footnote

4 Honeywell EGPWC, part number 965-1198-005.

5 The snapshot covers the time period from approximately 20 seconds prior to a warning having been generated, to 10 seconds after it has ceased. Each snapshot contains parameters recorded at a rate of once per second.

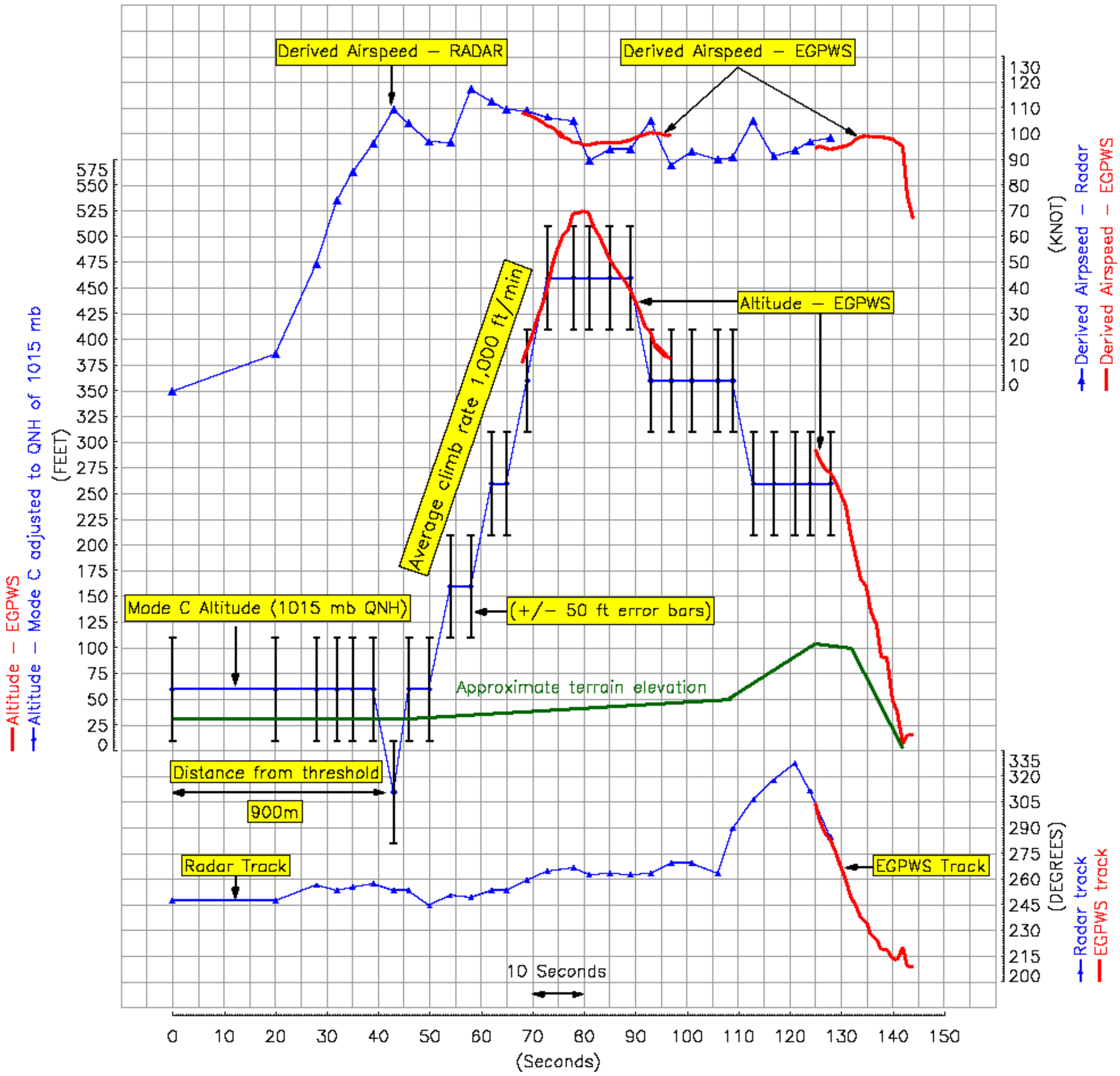

Figure 1

Recorded data for takeoff from Bournemouth Airport Runway 26
and descent into the field

Figure 2

Aircraft track (Radar in yellow and EGPWS in blue)

Interpretation of data

The Mode C altitude readout, which is based on a sea level pressure setting of 1013 hPa, was adjusted to a QNH value of 1015 hPa and an approximate airspeed was derived from the radar and EGPWS groundspeeds, based on a wind of 230° at 10 kt. At approximately 1128:08 hrs, the aircraft was positioned on the threshold of Runway 26. After 20 seconds, the first radar point was recorded as the aircraft commenced its takeoff run. Due to the +/- 50 ft quantisation of Mode C altitude, it was not practicable to determine the exact point on the runway that the aircraft left the ground. However, when the aircraft was approximately 900 m (2,953 ft) from the threshold, and at an airspeed of about 109 kt, there was a momentary decrease in the Mode C altitude from 60 ft to 10 ft, which is indicative of rotation for takeoff. Four seconds later, approximately 1,090 m (3,575 ft) from the threshold, the adjusted Mode C altitude returned to 60 ft (+/- 50 ft) (the runway elevation is approximately 30 ft at this point). After takeoff the aircraft drifted left of the runway[6], tracking approximately 255°(M), and was displaced to the south of the centreline by approximately 120 m when it passed the upwind threshold.

Footnote

6 The runway is on a magnetic bearing of 257°.

During the 30 seconds after lift-off, the average climb rate (based on the Mode C altitude) was approximately 1,000 ft/min. As the aircraft climbed, its airspeed reduced progressively and, at an altitude of 525 ft, its airspeed was about 97 kt. The aircraft levelled off briefly before descending and an EGPWS Mode 1[7] SINK RATE warning was generated with the aircraft at an altitude of 460 ft and with a descent rate of about 540 ft/min. As the aircraft descended, its airspeed stabilised at about 100 kt. At 1.2 nm from the end of Runway 26, and at an altitude of about 350 ft, the aircraft made a right turn onto a track of 330°. This was shortly followed by a left descending turn from an altitude of 290 ft (170 ft agl) onto a track of about 215°. As the aircraft banked to the left, the airspeed was maintained between 96 kt and 100 kt, but the rate of descent increased progressively to about 1,000 ft/min. Shortly before impacting the line of trees, the descent rate was reduced; the airspeed was approximately 98 kt at the time. The estimated groundspeed at touchdown was 88 kt and the aircraft was airborne for approximately 95 seconds.

Propeller checks

The propeller control lever controls propeller rpm through the primary governor. Should the primary governor malfunction and command more than 2,200 rpm, an overspeed governor prevents the propeller speed from exceeding approximately 2,288 rpm. A PROP GOV TEST switch resets the overspeed governor threshold to between 1,960 and 2,140 rpm. During the before takeoff propeller check on each engine, the propeller lever is moved fully forward and, with propeller rpm set below 1,900 by the power lever, the PROP GOV TEST switch is held ON. The power lever is moved forward until the propeller rpm stabilises between 1,960 and 2,140 rpm to confirm correct operation of the overspeed governor.

Engine power

The power of a turboprop powerplant measured in shaft horsepower (shp) is proportional to the product of torque and rpm. The Airplane Flight Manual (AFM) gives two torque limits, corresponding to two rpm settings, each of which will produce a power output of 550 shp: 1,315 ft-lb of torque at 2,200 rpm and 1,520 ft-lb of torque at 1,900 rpm. The takeoff torque limit was shown as a solid red line on each engine's torque gauge on the instrument panel and the higher torque limit was shown as a dotted red line. The AFM technique for selecting takeoff rpm was for the propeller levers to be fully forward to allow the primary governor to maintain 2,200 rpm.

With the rpm levers fully forward, the primary governors will maintain the propellers at 2,200 rpm when the power levers are advanced for takeoff. With the rpm levers slightly aft of fully forward, propeller speed during takeoff will be less than 2,200 rpm and, if the power levers are used to set 1,315 ft-lb of torque, the power output of each engine will be less than 550 shp. Small movements of the rpm levers do not command large changes in rpm, and moving the rpm levers aft by half an inch, or even slightly more, is unlikely to reduce the power significantly, although the propeller efficiency may be reduced. When rpm is reduced there is a small increase in torque, and vice versa, but it is movement of the power levers that has the greatest effect on the power output.

Takeoff performance

The takeoff and climb performance figures in the AFM assume a power setting of 1,315 ft-lb of torque with

Footnote

[7] An EGPWS Mode 1 (Excessive rate of descent) aural alert – "SINK RATE" – is generated after takeoff if a rate of descent develops that exceeds a threshold value. The threshold value increases with height above the ground.

2,200 rpm and a lift-off speed of 95 kt IAS. With an actual takeoff weight of 10,071 lb[8], the distance to lift-off should have been approximately 1,350 ft, the two engine climb rate should have been approximately 1,850 ft/min and the single engine climb rate should have been approximately 470 ft/min.

The pilot could not recall the exact point on the runway that he applied power but the aircraft was moving as he did so. From groundspeed information attached to the radar data, it was judged that the pilot began to accelerate approximately 400 ft from the threshold of Runway 26 and this was assumed to be the start of the takeoff run. Mode C and radar information suggested that the aircraft rotated approximately 2,500 ft from the start of the takeoff at approximately 109 kt. Radar data suggested that the aircraft was travelling at 95 kt IAS approximately 2,100 ft from the start of the takeoff run, and that the initial climb rate was approximately 1,000 ft/min.

Analysis

The takeoff performance calculation indicated that the aircraft should have lifted off at 95 kt after a ground run of 1,350 ft. Radar data suggested that it took approximately 2,100 ft to accelerate to 95 kt (although the pilot actually rotated at a reported 104 kt). This was considered to be a sufficiently reliable indication of the actual distance to 95 kt to confirm a lack of performance on the runway. The symptoms described by the pilot suggested a symmetrical power reduction rather than the failure of a single engine, and the drift to the left shortly after takeoff was considered to be the result of the aft movement of the left engine power lever while the pilot raised the landing gear. Symmetrical power loss is unusual and suggestive of fuel contamination but, as fuel contamination was discounted earlier in this report, the following section discusses the powerplants and engine handling.

Examination of the engines and testing of the accessories revealed nothing that could have had a bearing on the accident. The pilot reported that the engines ran normally before takeoff and that there were no warnings or cautions during or after takeoff. It was concluded that, in all probability, the accident was not caused by a fault in either engine.

The maximum power that the powerplants could have been producing during takeoff was probably slightly less than 550 shp because the rpm levers were not fully forward when the pilot set the torque. The pilot's recollection that the levers were approximately half an inch aft of fully forward was not accurate enough to give a reliable estimation of the rpm and, by inference, the power actually used. It seemed unlikely, however, that the reduction in rpm was sufficiently large to explain the reduction in performance.

The reduced power during takeoff would also have reduced the aircraft's climb performance after takeoff, although this might have been masked immediately after lift-off because the pilot rotated at approximately 104 kt, not 95 kt, which would have increased the initial climb rate. When he judged that the aircraft was not climbing as expected, the pilot pushed the power levers forward, which would have increased torque, and brought the rpm levers back, which would have reduced rpm and led to a slight increase in torque. The net effect of these actions on the overall power output was not determined but, if it was positive, it was evidently not sufficient to prevent the aircraft from descending.

Power levers are the major determinant of power output and the pilot was insistent that he set the torque

Footnote

[8] The maximum takeoff weight for the aircraft is 10,100 lb.

to the takeoff limit. Consequently, the investigation had insufficient evidence to determine the cause of the accident with any degree of certainty.

The pilot, faced with a lack of power and performance, made a positive decision to make a forced landing into a field. He did not allow himself to become distracted from the primary task of flying the aircraft and maintained a safe flying speed throughout, which ensured that the aircraft remained under control down to the ground. Had this not been the case, the outcome might have been less favourable.

Conclusions

The pilot experienced symptoms of symmetrical power loss sufficient to prevent the aircraft from sustaining level flight and made a forced landing into a field. The deficiency in the aircraft's takeoff performance suggested that its powerplants were not producing sufficient thrust. As fuel contamination was discounted and no fault was found in either engine, it was concluded that, in all probability, the poor performance was not caused by a failure in either powerplant. Maximum rpm was not selected for departure but it was unlikely that this explained the aircraft's poor performance on the runway or in the air. The pilot insisted that he had set torque to the takeoff limit. There was insufficient evidence to enable the cause of the apparent power loss to be determined.