ACCIDENT

Aircraft Type and Registration:	Piper PA-23-250, G-BJNZ	
No & Type of Engines:	2 Lycoming IO-540-C4B5 piston engines	
Year of Manufacture:	1979 (Serial no: 27-7954099)	
Date & Time (UTC):	2 April 2022 at 1535 hrs	
Location:	Enfield, Greater London	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to the engines, propellers, landing gear, left flap and underside of the fuselage	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	67 years	
Commander's Flying Experience:	1,859 hours (of which 1,090 were on type) Last 90 days - 33 hours Last 28 days - 21 hours	
Information Source:	AAIB Field investigation	

Synopsis

During an IFR flight from Le Touquet to Wellesbourne, the pilot observed oil leaking from the left engine followed by engine vibration. He shut the engine down and descended but elected to continue the flight toward Wellesbourne. On reaching 2,000 ft he found he was unable to maintain level flight on one engine and decided to land in a field.

The investigation found the left engine failed due to a fatigue crack in one of the cylinder barrels. It is likely that the pilot was unable to maintain level flight on the right engine due to a combination of engine wear resulting in reduced power available and the prevailing weather conditions. His decision to continue the flight following the engine shutdown was likely to have been influenced by high workload and plan continuation bias.

The maintenance organisation has taken safety action to enhance its maintenance programme for aircraft fitted with piston engines operating beyond the manufacturer's recommended overhaul life.

History of the flight

The pilot and three passengers were taking part in a flying club 'fly-out' from Wellesbourne Mountford Airfield to Le Touquet in France. The pilot planned to fly in controlled airspace under IFR. The other aircraft involved in the fly-out were all flying under VFR[1]. G-BJNZ's outbound flight to Le Touquet was uneventful, landing in Le Touquet at 0830 hrs.

Footnote

[1] One of the other aircraft taking part in the fly-out, G-EGVA, was involved in a separate accident during the flight to Le Touquet. That accident is subject to a separate AAIB investigation.

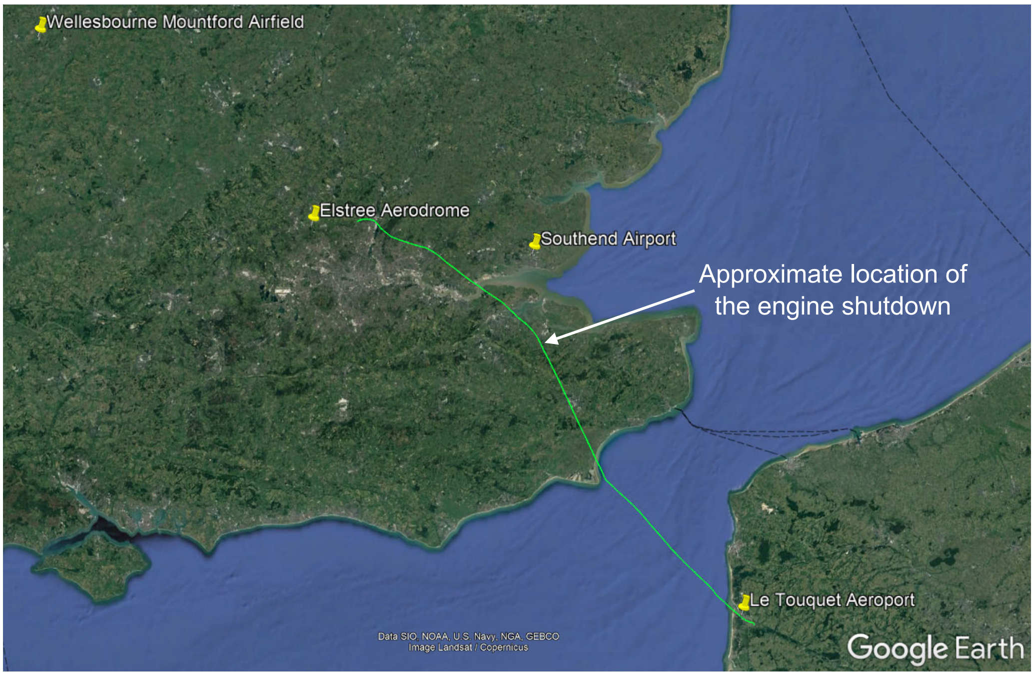

Figure 1

G-BJNZ radar trace showing the intended destination

G-BJNZ took off for the return flight to Wellesbourne at 1422 hrs. The pilot followed a standard instrument departure and climbed to FL90 routing towards Lydd then Detling (the route flown is shown in Figure 1). The pilot reported that at FL90 he was above the convective weather present in the English Channel on the day. As the aircraft approached DET, still at FL90, the pilot observed oil leaking from the left engine (Figure 2). The oil pressure, oil temperature and cylinder head temperature indications were normal, but oil was clearly visible on the engine cowling. Shortly afterwards the left engine started to vibrate, so the pilot elected to shut the engine down and feather the propeller.

The pilot informed ATC that he had shut down the left engine and told them he needed to descend. ATC cleared the aircraft to descend to 5,000 ft and asked the pilot if he wished to declare an emergency and if he would like to divert to Southend Airport which was approximately 15 nm north of his position. The pilot made a PAN call but stated that he was happy to continue to Wellesbourne. He requested a further descent to 4,000 ft, routing to the south of Stapleford Airfield and requested a routing through Luton Airspace, which was granted. The pilot then requested a further descent out of controlled airspace and cancelled his IFR flight plan. ATC queried the pilot about this intention but the pilot confirmed that this was his preference.

The pilot attempted to stop the descent at 2,000 ft amsl but when he tried to fly level the aircraft lost airspeed despite full throttle on the right engine. The pilot was not able to make the aircraft climb or maintain altitude without losing airspeed. By this stage the aircraft was east of Elstree Aerodrome, so the pilot flew directly to Elstree and informed them he needed to land immediately. However, he realised he was losing too much altitude and would not be able to reach the aerodrome.

Figure 2

Photograph taken inflight of the oil leak from the left engine

He identified a grass field on his left side with an upslope and no obstructions, and positioned the aircraft for landing. When he was confident that he would reach the field, he lowered the landing gear. The aircraft then landed heavily in the field and the landing gear collapsed, after which the aircraft slid to a stop in approximately 100 m. When the aircraft stopped the pilot shut off the fuel and electrics. None of the occupants were injured and they were all able to exit the aircraft.

Figure 3

Radar trace following the engine shutdown showing altitude

Information provided by the pilot

The pilot reported that he did not know why the aircraft did not maintain height on one engine. He considered he was experienced at flying the Piper Aztec and had flown this aircraft many times on one engine during training and revalidations without difficulty. He thought the aircraft might have been affected by downdrafts from cumulonimbus activity in the area.

After the off-aerodrome landing the pilot thought about why he had not diverted to the nearest suitable aerodrome after he had shut down the left engine. ATC had asked if he would like to route to Southend. At the time he thought the aircraft was flying normally on one engine and the operating engine was showing no adverse effects, so he believed he could safely continue to his planned destination. He felt his previous experience of flying on one engine during training flights had given him confidence that he could continue safely.

Recorded data

The attitude flown by the aircraft was recorded on radar (Figure 3) and is shown in profile in Figure 4. Average rates of descent are shown in red. The figure shows that on passing 2,000 ft the aircraft initially continued to descend at 200 ft/min before climbing briefly then descending again.

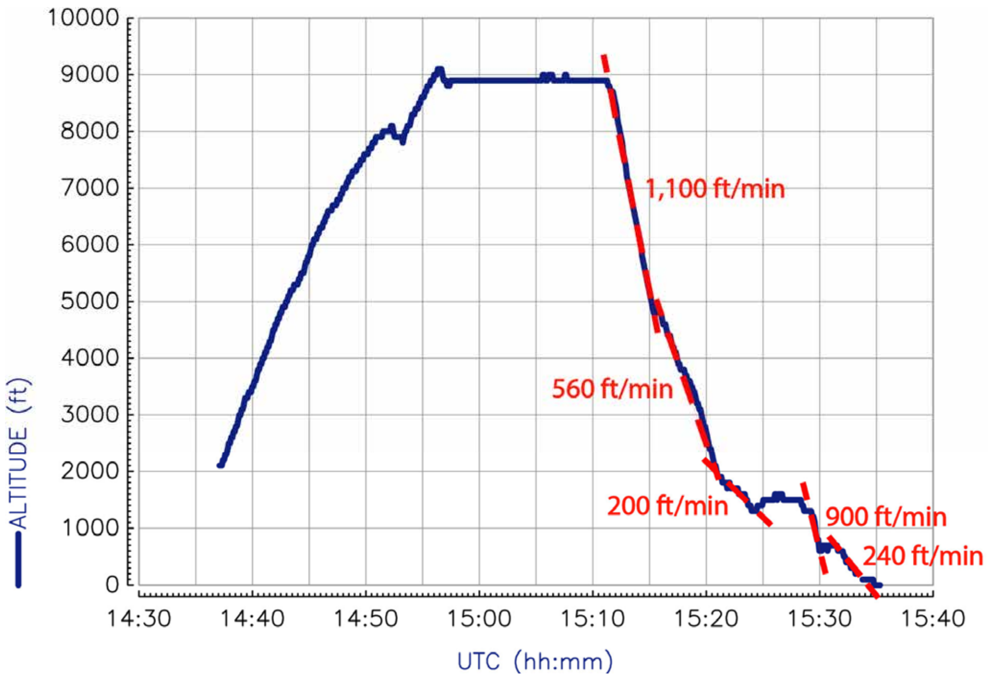

Figure 4

Altitude profile of the accident flight

Accident site

The aircraft landed in a grass field near Enfield, Greater London, approximately 7.8 nm from Elstree Aerodrome (Figure 5). Ground marks made by the aircraft showed that the landing gear had been extended at touchdown, before it had then rapidly collapsed. The right main and nose landing gear legs were pushed upwards into their landing gear wells and the left main leg had detached. The left flap was partially detached from the wing.

Figure 5

G-BJNZ following the forced landing

The left propeller was feathered. The right propeller blades exhibited leading edge damage, chordwise scoring and were bent rearwards, consistent with rotation under low power during the landing roll. The left engine cowlings were removed, revealing that the top section of the No 5 cylinder[2] had fractured and separated from the engine, exposing the top of the piston (Figure 6). One quart of oil remained in the left engine. The right engine was examined and no significant external defects were apparent.

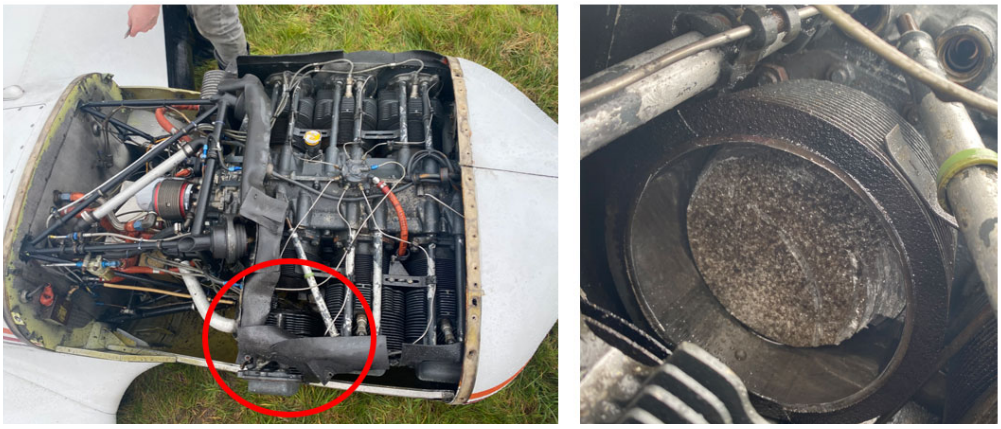

Figure 6

Left engine fractured No 5 cylinder and exposed piston

Footnote

2 Cylinder 5 is the rear right cylinder, when viewing the engine from above.

Aircraft information

The Piper PA-23-250 is a six-seat light aircraft powered by two piston engines driving variable-pitch constant-speed propellers. As both propellers rotate clockwise, the aircraft's left engine is the 'critical engine'[3]. The aircraft is of conventional light-alloy construction with a retractable tricycle landing gear. The CAA categorises the aircraft as a UK Part 21[4] light aircraft.

At the aircraft's last annual inspection in March 2022, its left and right engines had recorded 2,212.7 hours-in-service. The engines were installed in the aircraft when it was built in 1979. The manufacturer's recommended overhaul life of the engines is 2,000 hours or 12 years, whichever occurs first.

Maintenance programme

The aircraft was subject to a maintenance programme developed to comply with the requirements of Part-ML[5]. The programme contained inspections at 50 hours, 150 hours and annual intervals. The aircraft owner had contracted with a Part-CAO[6] organisation to manage the aircraft's continuing airworthiness and maintenance programme, and to perform the required maintenance.

Part-ML and Part-CAO were introduced by the CAA on 24 March 2021. Prior to this, the CAA approved the maintenance programmes for light aircraft and published Generic Requirements (GRs) that contained additional maintenance requirements. After the introduction of Part-ML, the content of CAA GRs, including GR No 24 (Light Aircraft Piston Engine Overhaul Periods)[7], was no longer mandatory for UK Part 21 aircraft.

GR No 24 provides guidance to aircraft owners and maintenance organisations for the inspection and operation of piston engines where the engines are operated beyond the manufacturer's recommended overhaul periods, either by operating time or calendar time. Appendix 3 of GR No 24 contains information for external and internal condition inspections, oil consumption monitoring and compression checks. This information relating to cylinder corrosion is:

> **3.1 External Condition.** The engine should be examined externally for obvious defects such as a cracked crankcase, excessive play in the propeller shaft, overheating and corrosion, which would make it unacceptable for further use.

Footnote

[3] The critical engine in a multi-engine aircraft is that which, in the event of its failure, requires the greatest control deflections to maintain lateral and directional control.

[4] Aircraft in this category are those that were previously managed by the EASA and were considered as EASA types. They are regulated under UK Regulation (EU) 2018/1139, known as the UK Basic Regulation, and its implementing regulations.

[5] Part-ML contains regulations for the maintenance of light aircraft to ensure that they remain airworthy and are in a condition for safe operation. It also establishes the responsibilities of persons and organisations involved in activities related to the continuing airworthiness of light aircraft.

[6] Part-CAO contains regulations for Combined Airworthiness Organisations (CAOs). CAOs may perform continuing airworthiness management organisation activities, or maintenance organisation activities, or both.

[7] Generic Requirement GR No 24 - Light Aircraft Piston Engine Overhaul Periods, Part 4, CAA CAP 747.

GR No 24 also describes a method to determine the power developed by a piston engine in which the maximum static engine rpm is recorded during a ground engine run, with a controllable-pitch propeller in the full fine position. The result is then compared to a reference speed recorded in the engine logbook. A reduction in engine power will result in a reduction in the maximum static engine rpm and a reduction of more than 3% is considered unacceptable, requiring defect rectification. An alternative method to determine engine power deterioration is to perform a rate-of-climb flight test, and to compare the result with figures in the aircraft's flight manual.

After the introduction of Part-ML, the Part-CAO organisation continued to include maintenance inspections from GR No 24 in G-BJNZ's maintenance programme, because the engines' time-in-service exceeded the manufacturer's recommended overhaul period.

Maintenance history

The maintenance organisation performed an annual inspection and ARC renewal in March 2022. The inspection included engine inspections in accordance with GR No 24 and there were no resulting findings, and the service life of the engines was extended for a further 12 months or 100 hours. A differential-compression test was performed on both engines, with results in a range of 72-80 psi for the left engine and 68-80 psi for the right engine. Neither set of compression test results indicated the need for further investigation of the engine cylinders. The inspection records stated that the oil filter elements were inspected and found to be clean of debris.

The annual inspection also involved ground-running the aircraft's engines and recording engine temperatures, pressures, magneto rpm drops and other data on a worksheet. The worksheet contained boxes for recording the maximum static rpm achieved by each engine, but no entries were recorded.

Aircraft examination

Left engine

The fracture in the No 5 cylinder occurred in the steel cylinder barrel, 13 mm from the point where the aluminium cylinder head is screwed onto the steel barrel (Figure 7). The crack started at the 1 o'clock point on the barrel section, on the upper part of the cylinder.

The fractured cylinder was examined by a metallurgist who concluded that the crack originated at a corrosion pit on the cylinder's outer surface (Figure 8). The steel barrels of all the other cylinders of both engines were inspected and all were observed to be corroded on their outer surfaces.

The fracture propagated by fatigue for approximately 50% of the cylinder cross-section (Figure 9). The fracture then continued to grow in a mixed fatigue-overload mode, before the cylinder finally failed in overload.

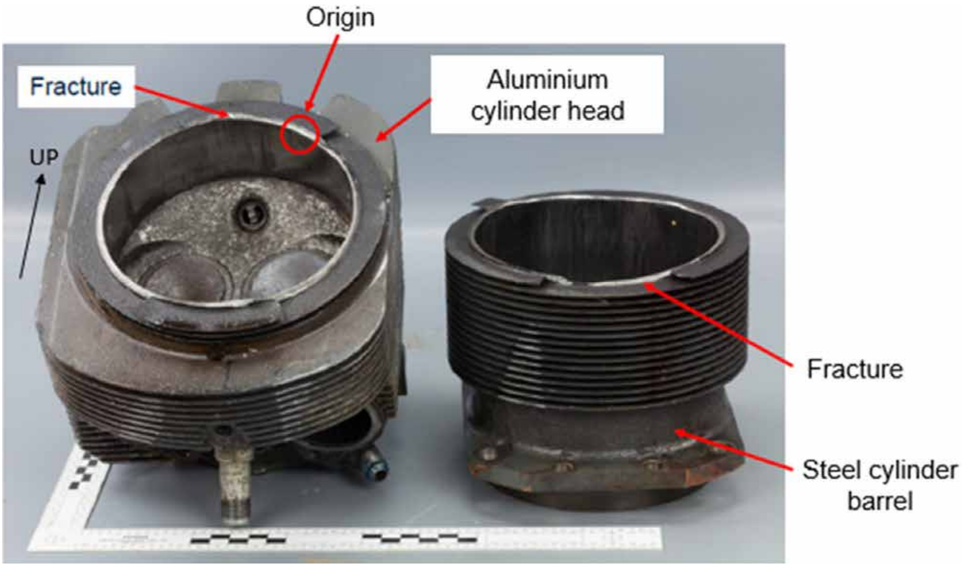

Figure 7

Fracture location in No 5 cylinder (image courtesy QinetiQ)

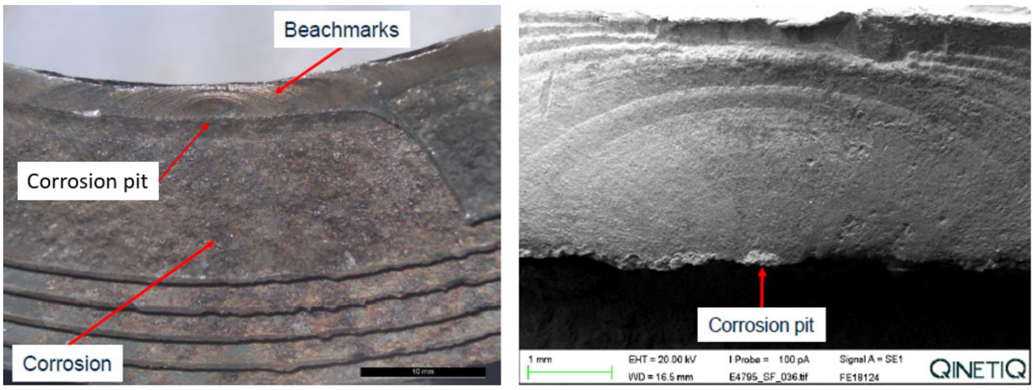

Figure 8

Corrosion pit at crack origin (images courtesy QinetiQ)

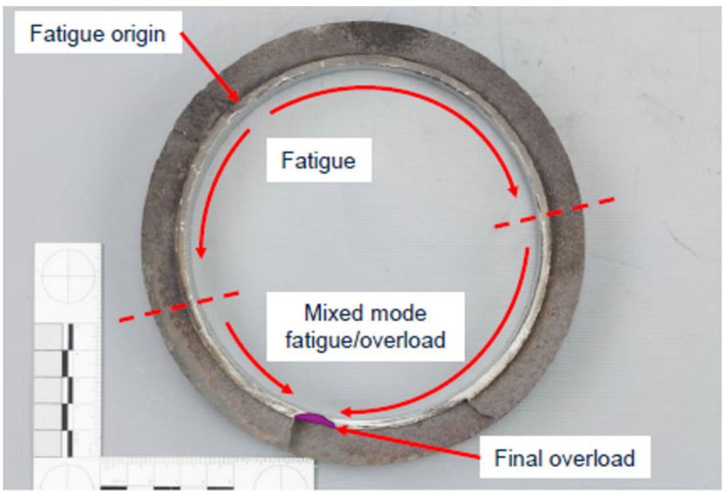

Figure 9

Crack growth progression (image courtesy QinetiQ)

The fracture surface was coated in a layer of lead bromide, a component of exhaust gases. The degree of coating varied along the fracture surface, with the heaviest deposits around the crack initiation site. This indicates that the cracking had occurred progressively, whilst the engine was operating, although it was not possible to accurately state when the cracking had started.

The licenced engineer who carried out the annual inspection stated that he had observed the visible corrosion on the cylinder barrels, but did not consider it sufficient to reject the cylinders. He also stated that cylinder corrosion was a common observation on the general aviation aircraft he performed maintenance on.

Right engine

The right engine was tested on a calibrated dynamometer to determine its power output. The engine initially ran very roughly, preventing safe operation of the dynamometer. The cause of the rough running was traced to three lead-fouled spark plugs[8] and once these were replaced with serviceable plugs the engine ran smoothly. The engine's power output was measured at 203 hp at 2,575 rpm. The engine's stated power output, as recorded on its data plate, is 250 hp at 2,575 rpm. G-BJNZ's right engine therefore produced 47 hp (19%) less than its stated power output.

The engine was disassembled to determine the condition of its components. Severe wear was noted on the second camshaft lobe, which actuates the inlet valves for both the No 1 and No 2 cylinders (Figure 10). The lift of this camshaft lobe was measured to be 0.178", which is approximately 50% of the lift of an unworn camshaft. The other eight camshaft lobes showed minor wear that would not have significantly affected the engine's performance.

The faces of the hydraulic tappet bodies for the No 1 and No 2 inlet valves, which are in direct contact with the second camshaft lobe, exhibited heavy surface spalling (Figure 11). The tappet bodies transmit motion of the camshaft into movement of pushrods that actuate the inlet and exhaust valves. The other tappet bodies exhibited surface spalling and visible wear which would require their rejection at engine overhaul.

Visible wear was also observed in the engine's cylinder bores, piston skirts, exhaust valve guides and crankshaft main bearings. These were assessed as common for an engine of similar operating hours and unlikely to significantly affect the engine's power output. A small quantity of ferrous metal particles was present in the engine's oil filter.

Footnote

8 The lead-fouled spark plugs were the lower spark plug for No 5 cylinder and the upper spark plugs for No 4 and No 6 cylinders.

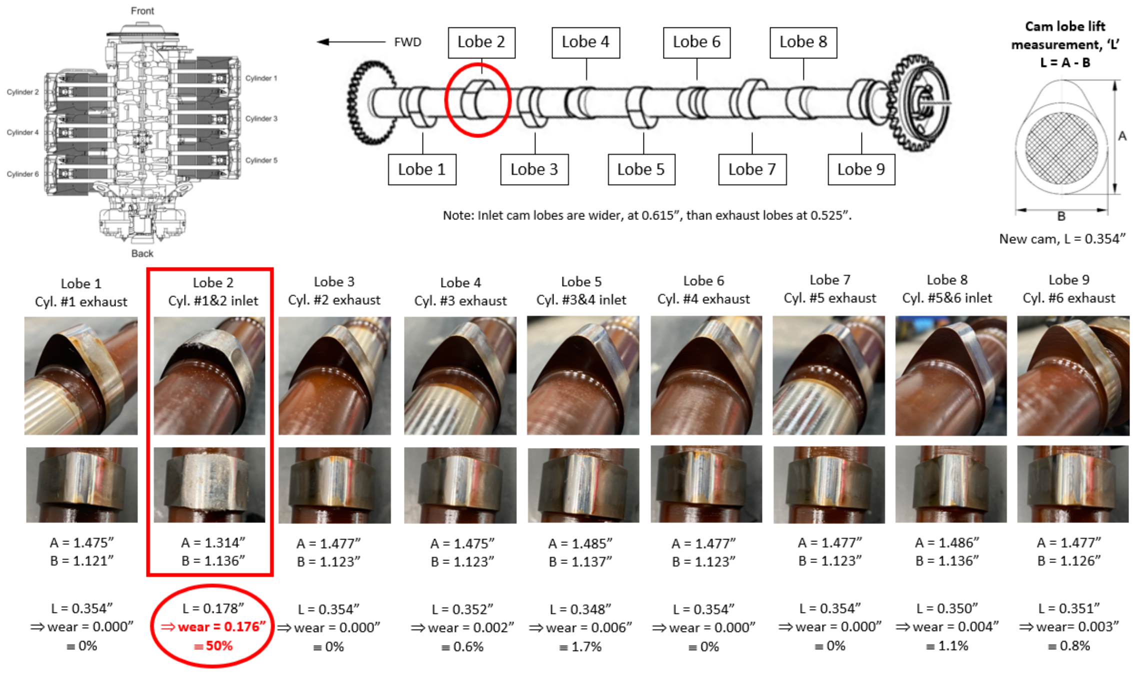

Figure 10

Measured wear of G-BJNZ's right engine camshaft lobes

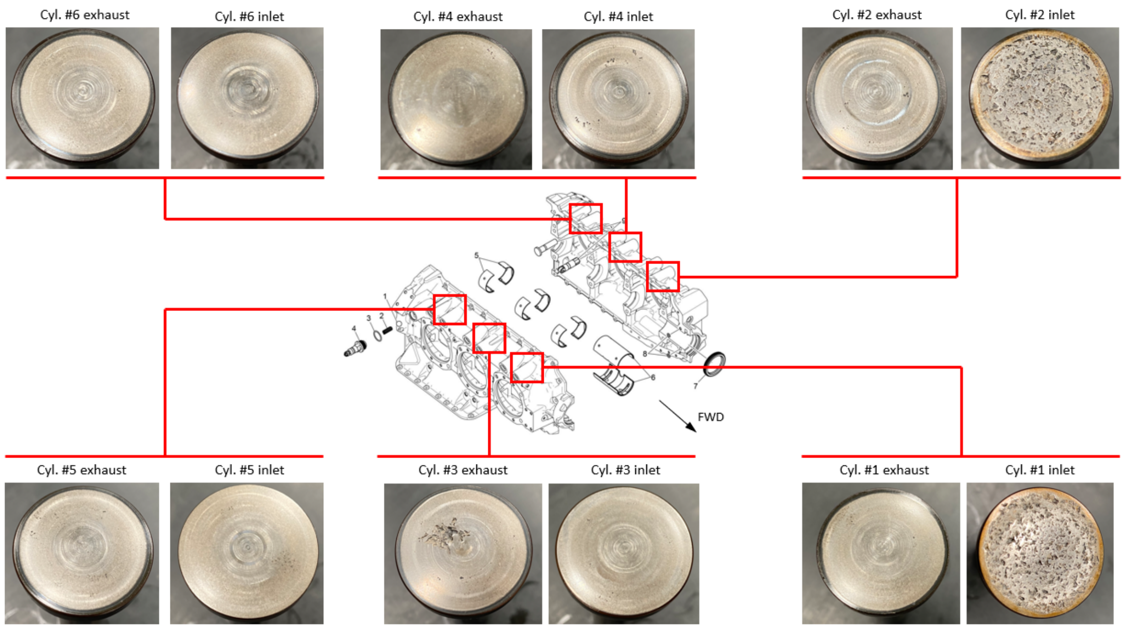

Figure 11

Observed wear of G-BJNZ's right engine tappet bodies

Pilot's operating handbook

The performance section of the Piper Aztec Pilot's Operating Handbook (POH) contains a graph giving expected single engine climb performance. The graph is based on a new aircraft with full throttle, fully rich mixture, cowl flaps fully open on the operative engine, landing gear and flaps retracted, the inoperative propeller feathered and 5º of bank towards the operative engine. At an altitude of 2,000 ft with an outside air temperature of 1ºC and an aircraft mass of 4,950 lbs the predicted climb performance is 250 fpm.

The emergency procedures section of the POH specifies the procedure to be followed following an engine failure during flight. The final line of the procedure states '*Land as soon as practical at the nearest suitable airport*'.

Meteorology

At the time of the accident rain showers where present across much of the UK. In the vicinity of the accident, satellite and radar records show cumuliform cloud and rain showers close to the aircraft's track. Figure 12 shows a weather radar image at 1530 hrs with the aircraft's track overlayed. Figure 2 shows the cloud ahead of the aircraft when the left engine was shutdown.

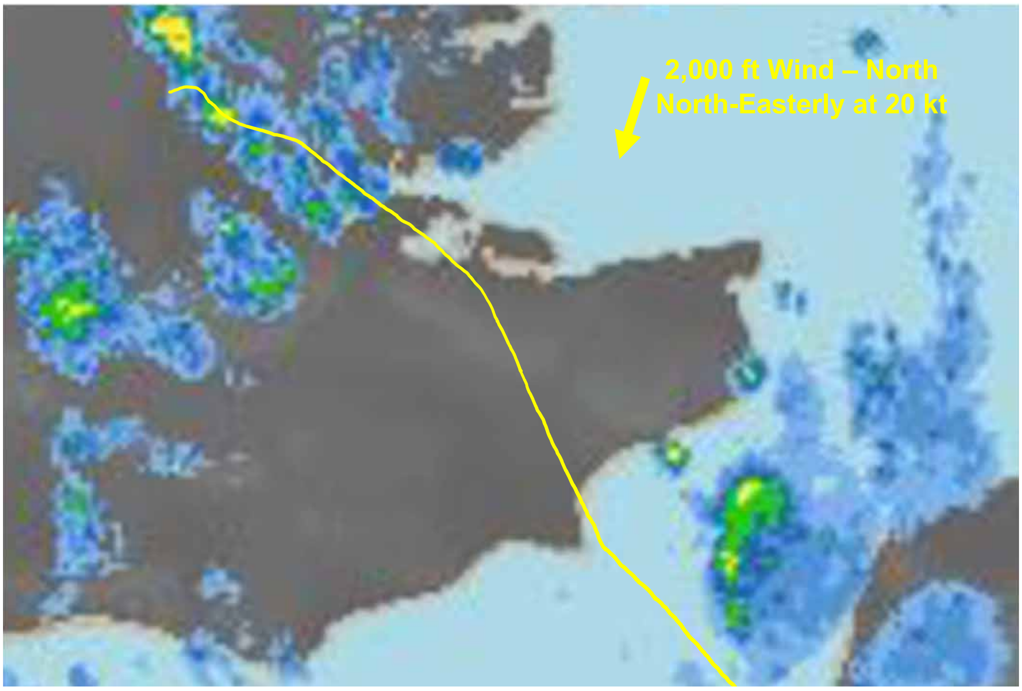

Figure 12

Weather radar image at 1530 hrs with the aircraft's track overlayed

Airports in the vicinity had forecast a risk of moderate showers throughout the period, with a smaller risk of heavier showers or thunderstorms. Towering cumulus was reported on an automatic METAR from London City Airport. Towering cumulus cloud can have strong downdraughts associated with them, which could affect any aircraft that was flying in close proximity.

At 1520 hrs Southend Airport was reporting a surface wind from 080º at 12 kt, visibility of more than 10 km with rain showers in the vicinity, no significant cloud and a temperature of 8ºC

The wind at 1,000 ft and 2,000 ft was forecast to be north-north-easterly at 20 kt. The temperature at 2,000 ft was forecast to be 1ºC.

Pilot information

The pilot held a private pilot's licence with a valid Multi-Engine Piston (MEP) rating and Instrument Rating (IR SP ME/SE). He was also a multi-engine and single engine class rating instructor. He held a valid Class 2 medical.

Decision making

The following description of pilot decision making was published in a Transportation Safety Board of Canada report into an accident which occurred in February 2018[9].

> *'To make decisions effectively, a pilot needs an accurate understanding of the situation and an appreciation of the implications of the situation, then to formulate a plan and contingencies, and to implement the best course of action. Equally important is a pilot's ability to recognize changes in the situation and to reinitiate the decision-making process to ensure that changes are accounted for and plans modified accordingly. If the potential implications of the situation are not adequately considered during the decision-making process, there is an increased risk that the decision and its associated action will result in an adverse outcome that leads to an undesired aircraft state.*
>
> *A number of different factors can adversely impact a pilot's decision-making process. For example, increased workload can adversely impact a pilot's ability to perceive and evaluate cues from the environment and may result in attentional narrowing. In many cases, this attentional narrowing can lead to confirmation bias, which causes people to seek out cues that support the desired course of action, to the possible exclusion of critical cues that may support an alternate, less desirable hypothesis. The danger this presents is that potentially serious outcomes may not be given the appropriate level of consideration when attempting to determine the best possible course of action.*
>
> *One specific form of confirmation bias is (plan) continuation bias, or plan continuation error. Continuation bias is best described as "the unconscious cognitive bias to continue with the original plan in spite of changing conditions" or "a deep-rooted tendency of individuals to continue their original plan of action even when changing circumstances require a new plan." Once a*

Footnote

9 Air Transportation Safety Investigation Report A18P0031, '*Loss of control and collision with terrain*', available at https://www.tsb.gc.ca/eng/rapports-reports/aviation/2018/A18P0031/A18P0031.html [accessed 23 June 2022]

plan is made and committed to, it becomes increasingly difficult for stimuli or conditions in the environment to be recognized as necessitating a change to the plan. Often, as workload increases, the stimuli or conditions will appear obvious to people external to the situation; however, it can be very difficult for a pilot caught up in the plan to recognize the saliency of the cues and the need to alter the plan.

When continuation bias interferes with the pilot's ability to detect important cues, or if the pilot fails to recognize the implications of those cues, breakdowns in situational awareness (SA) occur. These breakdowns in SA can result in non-optimal decisions being made, which could compromise safety.

In a NASA and Ames Research Center review of 37 accidents investigated by the U.S. National Transportation Safety Board, it was determined that almost 75% of the tactical decision errors involved in the 37 accidents were related to decisions to continue on the original plan of action despite the presence of cues suggesting an alternative course of action. Dekker (2006) suggests that continuation bias occurs when the cues used to formulate the initial plan are considered to be very strong. For example, if the plan seems like a great plan, based on the information available at the time, subsequent cues that indicate otherwise may not be viewed in an equal light, in terms of decision making.

Therefore, it is important to realize that continuation bias can occur, and it is important for pilots to remain cognizant of the risks of not carefully analysing changes in the situation, and considering the implications of those changes, to determine whether or not a more appropriate revised course of action is appropriate. As workload increases, particularly in a single-pilot scenario, less and less mental capacity is available to process these changes, and to consider the potential impact that they may have on the original plan.'

Analysis

Engine Failure

The left engine failed as a result of a fatigue crack in the steel barrel section of the No 5 cylinder, originating at a corrosion pit. The differential-compression test carried out at the annual inspection did not identify low compression in the cylinder and it is possible that the crack developed during operation of the aircraft after the annual inspection was carried out.

The licenced engineer who carried out the inspection did not consider the surface corrosion present on the cylinders to be a cause for their rejection. The guidance material in GR No 24 relating to corrosion does not contain any quantitative limits on the acceptable degree of cylinder corrosion. Cylinder corrosion is a common observation in the UK general aviation fleet and the CAA stated to the AAIB that assessment of the degree of cylinder corrosion, and any resulting decision to reject cylinders due to excessive corrosion, remains within the engineering judgement of licenced engineers.

Decision making

Once the pilot had shut down the left engine he decided to descend out of controlled airspace and continue the flight to Wellesbourne. However, the POH states that the pilot should land as soon as practical at the nearest suitable airport following an engine shutdown. Southend Airport was the closest airport and had suitable weather. There were also several other suitable airports in the vicinity.

Having suffered an engine failure whilst flying as sole pilot under IFR it is likely the pilot was experiencing a high workload and that this affected his ability to decide on the best course of action. Deciding on, and implementing, a new plan requires cognitive effort. This can be difficult when workload is already high and a pilot has limited spare capacity. Continuing with the current plan can seem like the best choice because doing so does not require additional thought and does not further increase workload. This is known as plan continuation bias. ATC offered a diversion to Southend but the pilot decided not to do this. When workload is high it is easy to discount external cues which suggest an alternative course of action.

Lack of climb performance

The aircraft's right engine was found to produce only 81% of its stated power output when tested after the accident. Severe wear of the second camshaft lobe was identified, which resulted in a significant loss of inlet valve lift for the engine's No 1 and No 2 cylinders. This is likely to account for most of the engine's power deficit, as no other major defects were noted when the engine was examined.

The right engine's power deficit was not identified during the annual maintenance inspection as the maximum static engine rpm was not recorded during engine ground runs. This meant that the opportunity to compare the maximum engine rpm with previous values or the engine logbook reference speed was missed.

When the pilot attempted to fly level at 2,000 ft, rain showers and cumulus cloud were close to the aircraft's track. These are likely to have generated downdrafts and turbulence. Any downdrafts would have further reduced the aircraft's ability to climb.

To achieve the climb performance stated in the POH the aircraft needs to be flown accurately in balance, with 5° bank to the live engine and at the correct speed (V_{YSE}). If the aircraft was flown above or below the correct speed the climb performance would have been reduced. Any turbulence is likely to have made it harder to fly the aircraft accurately.

The left engine is the critical engine, meaning more rudder deflection is required to maintain controlled flight. More rudder deflection means more drag and therefore less climb performance.

It is likely that the lack of climb performance resulted primarily from a reduction in maximum engine power caused by mechanical degradation. The weather conditions are also likely to have made it harder to achieve a positive climb.

Conclusion

The left engine failed due to a fatigue crack in one of the cylinders. It is likely that the pilot was unable to maintain level flight on the right engine because of a combination of engine wear and the weather conditions.

The pilot's decision to continue the flight following the shutdown of the left engine may have been influenced by high workload and plan continuation bias.

Safety actions

The aircraft's maintenance organisation has amended its maintenance programme for aircraft fitted with piston engines operating beyond the manufacturer's recommended overhaul life. The revised maintenance programme includes a rate-of-climb air test to detect a loss of engine power output and introduction of an oil sample analysis monitoring programme.

Published: 5 January 2023.