ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BSPM
No & Type of Engines:	1 Thielert TAE 125-02-99 piston engine
Year of Manufacture:	1981
Date & Time (UTC):	5 November 2010 at 1545 hrs
Location:	Ranmoor Common Road, Dorking, Surrey
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Minor) Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	800 hours (of which 387 were on type) Last 90 days - 70 hours Last 28 days - 16 hours
Information Source:	AAIB Field Investigation

Synopsis

During a training flight the aircraft experienced a rapid loss of engine power. The instructor took control and made a forced landing in a ploughed field during which the aircraft became inverted. The loss of power was attributed to a failure of the propeller reduction gearbox due to oil loss from a cracked union on the oil cooler. Analysis of data recorded by the engine's Full Authority Digital Engine Control (FADEC) unit confirmed that a defect within the propeller system had been apparent prior to takeoff and that the engine had been 'overspeeding' shortly after commencing the takeoff. No warnings or cautions were observed by the pilot or instructor until approximately 20 seconds before the loss of engine power.

History of the flight

The flight had been planned as a training exercise to simulate deteriorating en route weather conditions. The pilot and instructor completed the pre-flight inspection together and no problems were identified. After carrying out the engine start and pre-flight '*FADEC AND PROPELLER ADJUSTMENT FUNCTION TEST*', the aircraft entered the runway where a pre-takeoff power check was carried out. No abnormal engine indications were observed during any of these checks. After takeoff, the flight appeared to progress normally. No warnings or cautions were observed until approximately 12 minutes into the flight when the Compact Engine Display (CED) caution light illuminated and remained lit. The instructor observed that the propeller reduction gearbox oil temperature

had increased and was in the amber range of the temperature gauge with no other changes in engine parameters being apparent.

A PAN was declared and the instructor decided to carry out a precautionary landing at Redhill Airfield, which was nearby. Approximately 20 seconds later, an audible power fluctuation was heard and the engine power gauge was observed to fluctuate between 5% and 8%. Both FADEC warning lights were flashing rapidly and the propeller rpm gauge was indicating 2,400 rpm. The instructor declared a MAYDAY and completed a forced landing in a ploughed field. After touchdown, the aircraft pitched forward and came to rest inverted. The instructor made the aircraft safe and remained with the student in the aircraft until the arrival of the emergency services. Both pilots suffered minor injuries.

Aircraft and engine description

The aircraft was a Piper PA-28-161 which had been re-engined with a Thielert TAE 125-02-99 piston engine. This was a liquid-cooled four-cylinder direct injection diesel engine which drove a variable pitch propeller through a reduction gearbox. The engine and propeller were controlled with a single 'thrust lever' which provided an input to a dual channel FADEC unit. This unit then optimised the engine speed and propeller pitch to match the pilot's control inputs.

The aircraft was fitted with a multi-function instrument which displayed the propeller rpm, engine load, reduction-gearbox oil temperature and pressure, and engine cylinder temperatures, Figure 1. Both propeller rpm and 'load' were displayed digitally and in the form of a strip of green LEDs. The propeller rpm LED strip

Figure 1

Typical Thielert TAE 125 engine layout instrumentation

was marked with the maximum propeller speed of 2,300 rpm, and a red LED at the end of the rpm LED strip illuminated if it exceeded this limit. The aircraft was also fitted with a 'lightpanel' which contained two FADEC warning lights, the FADEC test knob and the CED caution light. In the event of a problem being detected within either channel of the FADEC unit, the associated FADEC warning light should flash. The CED caution light was designed to illuminate when an engine parameter exceeded its normal operational range. In addition, the CED caution light was designed to illuminate if the propeller speed remained between 2,301 rpm and 2,400 rpm for 20 seconds, or if it exceeded 2,401 rpm for two seconds.

The operation of the Thielert TAE 125-02-99 engine is detailed in the approved supplement to the aircraft's Pilot Operating Handbook (POH) and includes all of the operating limitations and checklists appropriate to the installation. Part of the pre-takeoff checks includes a *'FADEC AND PROPELLER ADJUSTMENT FUNCTION CHECK'*. This test involves pressing and holding down the FADEC knob on the 'lightpanel'. The FADEC then runs through a series of tests of the engine and propeller control systems, using each FADEC channel in turn. During the check, the respective FADEC channel warning light illuminates and the engine rpm increases to allow the propeller pitch control system to be tested. On completion of the test, the engine returns to its idle speed and both FADEC lights should be OFF. If either or both FADEC warning lights flash after the test, this indicates that a fault has been detected and the flight should not be continued. The final step of this check is to advance the thrust lever to its maximum power position and confirm that the engine is producing a minimum of 94% load with a propeller speed between 2,240 rpm and 2,300 rpm. There is no specified minimum duration for this test and the checklist used by the instructor during the accident flight stated that its duration should not exceed 10 seconds.

Investigation

The aircraft was examined in situ by its maintenance organisation and subsequently recovered to their facility for detailed examination. The engine gearbox was removed and sent to the manufacturer for further assessment. The manufacturer was able to determine that a failure within the gearbox had resulted in the loss of engine power. This failure was attributable to the loss of gearbox oil from a cracked union on the gearbox oil cooler. The mounting bracket for the oil cooler was found to have broken, allowing the cooler to move, which resulted in the cracking of the union. It could not be determined when the mounting bracket failed. The instructor confirmed that the gearbox oil level had appeared normal during the pre-flight inspection and there had been no evidence of an oil leak. An inspection of the aircraft's parking place confirmed that no oil was present on the hard standing.

A download of the engine's FADEC provided a significant amount of information regarding the engine's performance. Analysis of this data showed that, during the pre-takeoff FADEC test, the propeller did not respond correctly to the commanded pitch changes. The data also showed that the pre-takeoff power check appeared to have been carried out approximately four and a half minutes prior to takeoff. This power check lasted for approximately four seconds and the propeller rpm reached 2,305 rpm for one second. This 'overspeed' was of insufficient magnitude and duration to cause the CED caution light to illuminate.

Approximately two seconds after starting the takeoff run the FADEC recorded the propeller speed exceeding

the 2,300 rpm limitation. The propeller remained in this overspeeding condition until the failure of the reduction gearbox approximately 12 minutes after takeoff. The instructor confirmed that the CED caution light had remained off until approximately 20 seconds before the loss of engine power. The reason why the CED caution light did not illuminate during the prolonged overspeed could not be determined.

The only other indication of the overspeed condition would have been the illumination of the small red LED at the end of the rpm indication strip and the reading on the digital rpm gauge which, due to the nature of such gauges, would have been continually changing. In addition, the propeller rpm and load gauge was located low on the instrument panel, Figure 1. A review of the POH supplement confirmed that pilots are only directed to check the propeller rpm during the *'FADEC AND PROPELLER ADJUSTMENT FUNCTION CHECK'*; during all other phases of flight the 'load' gauge is the primary means of confirming engine power.

The recorded data also showed that the reduction gearbox oil temperature continued to rise until approximately 12 minutes after takeoff when the first FADEC warning, regarding gearbox oil temperature, was generated and the CED caution light was seen to come on and remain illuminated.

Conclusions

The loss of gearbox oil from the cracked oil cooler union resulted in a loss of oil pressure and subsequent failure of both the propeller control system and, ultimately, the reduction gearbox. It is probable that the failure of the oil cooler mounting bracket allowed sufficient movement of the oil cooler to cause the union to crack. The timing and reason for the failure of the bracket could not be determined.

The lack of evidence of an oil leak during the pre-flight inspection and the failure of the propeller to change pitch correctly during the pre-takeoff test suggest that the union cracked at some point between starting the engine and completing the FADEC test. The loss of gearbox oil resulted in the eventual failure of the reduction gearbox and subsequent loss of power.

The failure of the propeller pitch change mechanism allowed the engine and propeller to overspeed during takeoff and in flight until the loss of engine power. The pilots were unaware of this problem until the CED caution light illuminated continuously, approximately 12 minutes into the flight. Had the CED caution light illuminated earlier, during the takeoff run or the initial stages of the climb, there may have been an opportunity for a precautionary landing to be carried out.