Aviation Investigation Final Report

Location:	Suffolk, New York	**Accident Number:**	ERA17LA203
Date & Time:	June 12, 2017, 06:15 Local	**Registration:**	N13306
Aircraft:	Cessna 172	**Aircraft Damage:**	Substantial
Defining Event:	Loss of engine power (total)	**Injuries:**	1 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

According to the private pilot, while en route during a cross-country personal flight, he heard a "loud pop," followed by the engine losing all power. He declared an emergency, unsuccessfully attempted to restart the engine, and turned the airplane toward a golf course. During the landing, the airplane struck a tree, which resulted in substantial damage to the right wing.

Postaccident examination of the engine revealed that the crankshaft gear alignment dowel, which sets the rotational alignment of the gear with respect to the crankshaft, had fractured; one half of the dowel was retained in the crankshaft and was contacting the gear, and the other half of the dowel was retained in the pilot flange hole. Examination of the fracture surface indicated that the dowel fractured in fatigue, initially in unidirectional bending that started on the side with the wear but transitioned to reverse bending fatigue before the final failure. Rub marks were observed on parts of the gear in contact with the crankshaft and along the interface between the gear and the lock plate.

This evidence indicates that the bolt that fastened the crankshaft gear to the crankshaft was either not torqued to the proper value during assembly or that the bolt was torqued to the proper value but gradually lost preload due to an installation error. With insufficient preload, the gear would have placed unintended stresses on the alignment dowel, which would have resulted in wear and its eventual failure due to fatigue. Factors that could result in a loss of preload include improper installation of the lock plate or damage or debris trapped between the gear and the counterbore recess, which would prevent proper seating of the gear.

An engine manufacturer's service bulletin (SB) described the proper procedure for evaluating the condition of the crankshaft and crankshaft gear and the proper procedure for attaching the crankshaft gear to the crankshaft. One step stated that after aligning the crankshaft gear with the crankshaft using the alignment dowel, the bolt should be tightened to 125 inch-lbs of torque, followed by several checks to ensure that the gear was properly seated. After those checks were made, the final step was to tighten the bolt to 204 inch-lbs of torque.

Examination of the gear did not reveal any indications of deformation or debris that would have prevented proper seating of the gear against the face of the crankshaft counterbore recess. The locking tab was bent, but the bend was not aligned with the tab's plastic hinge. Presumably the bend was aligned with a flat face of the bolt head. It is likely that aligning the bolt with the flat face of the bolt head instead of with the tab's plastic hinge allowed the bolt to lose torque. It is also possible that, after applying the initial torque and checking whether the gear was properly seated, the final torque to 204 inch-lbs was not applied.

In conclusion, the engine failed when the crankshaft gear alignment dowel failed, which allowed the gear to rotate independently of the crankshaft and shifted the timing of the engine's crankshaft to its camshaft, which resulted in a total loss of engine power. The alignment dowel failed due to unintended loads from the crankshaft gear, which resulted in the dowel wearing and eventually failing in fatigue. The unintended loads likely resulted from the improper installation of the crankshaft bolt and locking tab, which led to insufficient torque being applied to the bolt during installation or an eventual loss of torque during subsequent engine operation.

A review of maintenance records revealed that the engine had been overhauled and that the engine failure occurred about 200 hours after the overhaul. The records did not specify compliance with the SB that provided the proper procedure for evaluating the condition of the crankshaft and crankshaft gear and the instructions for installing the crankshaft gear to the crankshaft.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

A loss of preload to the crankshaft gear attachment bolt due to improper installation, which resulted in the fatigue failure of the crankshaft gear alignment dowel and led to the rotation of the crankshaft gear and a subsequent total loss of engine power.

Findings

Personnel issues	Installation - Maintenance personnel
Aircraft	Recip eng rear section - Failure
Environmental issues	Tree(s) - Contributed to outcome

Factual Information

History of Flight

Enroute-cruise	Loss of engine power (total) (Defining event)
Enroute-cruise	Attempted remediation/recovery
Landing	Off-field or emergency landing
Landing-landing roll	Collision with terr/obj (non-CFIT)

On June 12, 2017, about 0615 eastern daylight time, a Cessna 172M, N13306, was substantially damaged during a forced landing to a golf course near Suffolk, New York. The private pilot was not injured. The airplane was registered to a corporation and operated by the pilot as a 14 *Code of Federal Regulations* Part 91 flight. Visual meteorological conditions prevailed at the time of the accident and no flight plan was filed for the personal flight. The flight originated from Brookhaven Airport (HWV), Shirley, New York, and was destined for Bayport Aerodrome (23N), Bayport, New York.

According to the pilot, the purpose of the flight was to purchase fuel at HWV and then return to 23N. While en route to 23N, he heard a "loud pop" and the engine experienced a total loss of power. The pilot checked the fuel selector and mixture, and then searched for a place to perform a forced landing. He declared an emergency, unsuccessfully attempted to restart the engine, and turned toward a golf course. During the landing, the airplane struck a tree, which resulted in substantial damage to the right wing.

According to Federal Aviation Administration (FAA) airworthiness records, the airplane was manufactured in 1973 and was originally equipped with a Lycoming O-320 engine. According to the maintenance records, the engine's most recent overhaul was completed on April 9, 2011. The maintenance log entry detailing the overhaul of the engine stated in-part, "Engine assembled and overhauled per Lycoming maintenance manual." The entry noted that several individual engine components were "overhauled" including the crankshaft and crankshaft gear. Airworthiness approval tags (FAA Form 8130-3) that documented the overhaul of the crankshaft and crankshaft gear noted in the remarks section, "Inspected and/or repaired per Lycoming SB 475 C excluding paragraph 6." The entry also noted the installation of several new parts to the engine, though the installation of a new crankshaft gear bolt and lockplate were not specifically called out. The entry further noted, "All ADs and SBs have been complied with thru 2011-6m." The entry did not explicitly state the final crankshaft gear bolt torque, note and verify the installation and bending of the lockplate against the bolt head, or that the inspections and rework required by Lycoming Service Bulletin Number 475C had been accomplished. At the time the engine was installed on the airplane it accumulated 4,337 hours of total time.

The most engine's recent 100-hour inspection was performed on June 15, 2016. At that time, the engine had accumulated 4,520.5 hours of total time, and 183.5 hours since major overhaul. There was a note in the engine maintenance log dated June 5, 2017, that indicated the engine had 216.5 hours since major overhaul. No other remarks were made next to that date.

Following the accident, the airplane was recovered from the accident site to a local maintenance facility. Fuel was plumbed to the engine and three unsuccessful attempts were made to start the engine. The left magneto was removed from the accessory drive section of the engine and the propeller was turned by hand. No rotation of the left magneto drive gear was noted. Then, the right magneto was removed and the propeller was again rotated by hand with no movement on the right magneto drive gear. Additional inspection revealed that the crankshaft drive gear was displaced from the aft end of the crankshaft. Further disassembly revealed that the crankshaft drive gear retention bolt had backed out about 0.25 inch but had some threads engaged in the crankshaft. The crankshaft gear bolt was removed, and the lockplate was in place and bent around the bolt, as stated in the manufacturer's service bulletin.

The dowel pin was confirmed to be part number STD-1065. Measurement of the remaining portions of the dowel pin found in the drive gear were measured at 0.245-inch, 0.241-inch, 0.240-inch, and 0.234-inch, which were all below the minimum diameter per the manufacturer's service bulletin of 0.3095-inch to 0.3100-inch diameter. In addition, no thread damage was noted on the bolt or the threaded portion of the aft crankshaft counterbore.

The crankshaft drive gear retention bolt was only marked with an "SL GR 8." According to the manufacturer's mandatory service bulletin, the crankshaft gear bolt "must be identified with 4 digit part number on head of bolt," which should have been 2246 for the accident airplane installation.

The crankshaft gear and its attaching hardware were forwarded to the NTSB Materials Laboratory for detailed examination.

According to the Materials Laboratory Factual Report, typically the crankshaft gear was mounted inside a counterbored pilot hole in the aft end of the crankshaft. The gear was pressed against the face of the recess by a bolt that engaged a threaded hole in the end of the crankshaft. A lockplate was installed between the bolt and the gear with ears that fold down against the side of the gear and up against the head of the bolt. The gear was rotationally aligned to the crankshaft by an alignment dowel. The alignment dowel from the accident engine was fractured, one end of the dowel retained inside the alignment hole in the gear, while the other end remained press-fit and retained in the end of the crankshaft.

The piece of the alignment dowel was extracted from the crankshaft gear hole with a punch and the fracture surface cleaned using standard laboratory procedures. The fracture surface, exhibited a flat appearance with multiple curved crack arrest marks progressing across the fracture. Multiple crack origin areas were observed on approximately opposite sides of the fracture. One crack from the origin area on the right covered about 80% of the fracture surface while the crack from the other origin area on the left side covered about 20% of the fracture. The dowel surface exhibited wear marks. On one side of the dowel, the wear had removed approximately 0.015 inch of material while the wear mark on the other side was comparatively superficial. Taken together, the features were consistent with a fatigue fracture of the alignment dowel that initially progressed under unidirectional bending and transitioned to reverse bending.

The pilot flange outer diameter exhibited rubbing damage along its interface with the crankshaft counterbore recess. Rub marks were also seen on the counterbore face of the pilot flange segments and at the interface between the lockplate and the gear. The tab on the locking plate was bent, but the bend was not aligned with the locking tab's plastic hinge.

Lycoming Engines provided guidance in the form of Service Bulletin No. 475C, which detailed procedure for attaching the crankshaft gear to the crankshaft during overhaul, following a propeller strike, or any other time when removal of the crankshaft gear was required. According to the bulletin, "Damage to the crankshaft gear and the counter-bored recess in the rear of the crankshaft, as well as badly worn or broken gear alignment dowels are the result of improper assembly techniques or the reuse of worn or damaged parts during reassembly. Since a failure of the gear or the gear attaching parts would result in complete engine stoppage, the proper inspection and reassembly of these parts is very important. The procedures described in the following steps are mandatory."

After aligning the crankshaft gear with the crankshaft utilizing the alignment dowel, paragraph 6 of the bulletin directed technicians to utilize a new bolt and lockplate, then tighten the bolt to 125 in.-lbs. of torque. The next step ensured proper seating of the gear by directing, "…with a hammer and brass drift, tap lightly around the pilot flange of the gear and listen for sharp solid sounds from the hammer blows that would indicate that the gear is seated against the crankshaft. As a check on the seating against the crankshaft, attempt to insert a pointed .001 inch thick feeler gage or shim stock between the gear and crankshaft at each of the three scallops. The .001 feeler gage, or any smaller feeler gage, must NOT fit between the two surfaces at any location (.001 feeler gage is used as an indicator, however, there must be no clearance between crankshaft and gear.)" Finally, the 5/16-inch bolt would be tightened to 204 in.-lbs. of torque, and the clearance between the outer diameter of the gear flange and the counter-bored pilot (inner diameter) of the crankshaft should measure no greater than 0.0005-inch at any point.

Upon completion of the installation the bulletin specified, "A logbook entry, specifying the final bolt torque, verifying that the lockplate was properly bent in place against the bolt head and that the inspections and rework required by Lycoming Service Bulletin No. 475C were accomplished, should be made and signed by an authorized inspection representative."

Pilot Information

Certificate:	Private	**Age:**	37,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Unknown
Other Aircraft Rating(s):	None	**Restraint Used:**	Unknown
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 3	**Last FAA Medical Exam:**	August 1, 2012
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N13306
Model/Series:	172 M	**Aircraft Category:**	Airplane
Year of Manufacture:	1973	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	17262654
Landing Gear Type:	Tricycle	**Seats:**	4
Date/Type of Last Inspection:	June 5, 2017 100 hour	**Certified Max Gross Wt.:**	2299 lbs
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:	4746.2 Hrs at time of accident	**Engine Manufacturer:**	LYCOMING
ELT:		**Engine Model/Series:**	O-320 SERIES
Registered Owner:		**Rated Power:**	
Operator:		**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	ISP,84 ft msl	**Distance from Accident Site:**	7 Nautical Miles
Observation Time:	05:56 Local	**Direction from Accident Site:**	291°
Lowest Cloud Condition:	Few / 25000 ft AGL	**Visibility**	8 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	4 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	240°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.02 inches Hg	**Temperature/Dew Point:**	20°C / 18°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	SHIRLEY, NY (HWV)	**Type of Flight Plan Filed:**	None
Destination:	BAYPORT, NY (23N)	**Type of Clearance:**	None
Departure Time:		**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 None	**Latitude, Longitude:**	40.750556,-72.948333(est)

Administrative Information

Investigator In Charge (IIC):	Kemner, Heidi
Additional Participating Persons:	Matt Cady; FAA/FSDO; Farmingdale , NY
Original Publish Date:	June 25, 2019
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=95349