Aviation Investigation Final Report

Location:	Phoenix, Arizona	**Accident Number:**	WPR20LA144
Date & Time:	May 13, 2020, 08:42 Local	**Registration:**	N201HH
Aircraft:	Mooney M20J	**Aircraft Damage:**	Substantial
Defining Event:	Powerplant sys/comp malf/fail	**Injuries:**	2 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot, who was also a longtime owner of the accident airplane, recently had the propeller and propeller governor overhauled by a service facility. During a subsequent attempted maintenance flight with his mechanic, they aborted the takeoff after having observed that the takeoff engine power was slightly lower than normal. After troubleshooting the discrepancy, and completing unreported adjustments to the governor, they returned to the runway to attempt another maintenance takeoff. During the initial stage of the takeoff roll, when an improvement in the engine power output was observed, the pilot elected to continue the takeoff. Subsequent to becoming airborne and after a short, uneventful flight, they decided to return to their departure airport, during which they observed a small engine overspeed. A few minutes later, they experienced catastrophic engine failure and performed a forced landing to rough terrain.

The engine was recently rebuilt by the engine manufacturer and accumulated only 170 flight hours prior to the accident. Engine monitoring data retrieved from the accident flight showed that a continuous rise in oil temperature began shortly before cylinder no. 4 stopped functioning, and the first indication of the engine failure. The other cylinders failed about 40 seconds later. This data also showed that cylinder no. 1 may have failed with cylinder no. 4, but this could not be corroborated by physical evidence. The engine examination revealed thermal and mechanical damage at the cylinder no. 3 and 4 connecting rod caps and bolts. This damage was consistent with high temperatures and an absence of lubrication during rotation.

A materials laboratory examination found that the cylinder no. 4 connecting rod cap had fractured from a fatigue crack that had initiated on the inner bearing surface of the part. The crack initiated at multiple sites along multiple parallel locations, which developed into parallel cracks. Once the largest fatigue crack had progressed through enough of the cap cross section, the remainder of the part fractured from overstress. Composition analysis of the fatigued area found an excessive, uniform layer of brominated tetraethyllead, consistent with improper

engine conditions such as oil starvation in this case. While a lack of lubrication due to a clogged oil hole is most likely to have led to the conditions observed, the damage to the oil holes on the connecting rod could not be determined due to plastic deformation damage on the journals; thus, the origin of the oil starvation is unknown.

Examination of the propeller and propeller governor did not reveal any anomalies that would have contributed to the total loss of engine power. An improper gasket had been installed on the face of the propeller governor, which lacked an inlet port filter. Although the gasket may have formed a seal between the governor and adapter, the absence of the filter likely allowed metallic fragments from the engine to enter the governor, which may have affected its operability.

Probable Cause and Findings

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

A total loss of engine power due to oil starvation for reasons that could not be determined due to a lack of available evidence, which resulted in impact with terrain during a subsequent forced landing.

Findings

Aircraft	Oil - Unknown/Not determined
Aircraft	(general) - Failure
Environmental issues	Rough terrain - Contributed to outcome

Factual Information

History of Flight

Maneuvering	Powerplant sys/comp malf/fail (Defining event)
Emergency descent	Loss of engine power (total)

On May 13, 2020, about 0842 mountain standard time, a Mooney M20J airplane, N201HH, was substantially damaged when it was involved in an accident near Phoenix Deer Valley Airport (DVT), Deer Valley, Arizona. The pilot and passenger were not injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

According to the pilot, who was also the airplane owner, the purpose of the accident flight was to test the airplane's performance following the reinstallation of the propeller and propeller governor, which had recently been overhauled. One week before the accident and after the reinstallation, the pilot and his mechanic performed multiple ground run-ups and subsequent propeller adjustments but were unable to achieve 2,700 rpm, the takeoff specifications for the engine. However, they observed that the engine power had reached 2,600 rpm and elected to see how the airplane performed during a takeoff roll.

The first takeoff attempt following the propeller overhaul was performed the day prior to the accident, but it was aborted after they observed a maximum engine output of only about 2,350 rpm. They subsequently returned to the pilot's hangar to perform additional adjustments to the propeller governor.

On the day of the accident, the pilot started the engine and taxied to runway 22 with the mechanic onboard where he performed an engine run-up; he did not observe any anomalies. During the takeoff roll, the engine reached 2,600 rpm, so they continued the departure and climbout. The engine did not show any unusual indications during this portion of the flight. Once they reached 6,000 ft. mean sea level, the pilot reduced the cruise power setting to 2,500 rpm and manifold pressure to 25 inches of Hg. As the cruise power setting appeared stable, the pilot elected to return to the departure airport; however, seconds later the engine overspeed to 2,850 rpm. The pilot then reduced manifold pressure to 15 inches of Hg and declared an emergency to the tower controller. The engine operation was erratic and continued to produce thrust but did not respond to their attempts to manipulate the propeller lever. They descended normally toward runway 25R at 2,500 ft about 2.5 nm from the airport. At this time, they experienced a total loss of engine power. The pilot attempted a forced landing to an area with minimal desert vegetation, but the airplane impacted rough terrain and came to rest.

Postaccident photographs provided by the Federal Aviation Administration (FAA) showed substantial damage to the stabilator.

The pilot owned the accident airplane for about 38 years and had not experienced any prior power management issues. According to maintenance records, the engine was overhauled by Lycoming Engines as a rebuild on July 11, 2014. A review of the maintenance history did not reveal any historical anomalies with the engine following its overhaul.

On April 14, the pilot of the accident airplane observed an oil leak from the propeller hub to blade seal and decided to have the propeller overhauled, as the last overhaul was completed about 973 flight hours and 18 years before the accident flight. The propeller and propeller governor were subsequently overhauled May 1, 2020, about 1.5 hours prior to the accident flight. According to the pilot, the propeller overhaul facility informed him that they would need to overhaul the governor simultaneously to synchronize it with the propeller during bench testing.

The pilot's mechanic and the pilot reinstalled the overhauled propeller and governor after they were returned from the overhaul facility. In the pilot's statement, he noted that they made several adjustments to the governor while attempting to reach the engine's rated rpm. When asked what adjustments were made to the governor, the pilot and mechanic did not recall, but the pilot reported that they removed a second gasket from the governor in order to install the unit on the accessory case of the engine.

An initial inspection of the engine revealed two large holes in the crank case. Additionally, metallic debris was observed throughout the oil pan, and the oil suction screen was obstructed with large metal particles. An interior examination of the mechanical components was performed after the case was disassembled, which showed that the cylinder no. 3 and 4 connecting rod caps and bolts had separated (see figures 1 & 2). According to the FAA's report, evidence showed that the internal damage to the engine was caused by a liberation of the cylinder no. 3 and 4 connecting rods from the crankshaft. The other connecting rods were unremarkable.

According to the FAA, Aviation Maintenance Technician Handbook – Powerplant, Volume 1 – FAA-H-8083-32A, the plain [connecting] rod is equipped with a cap and connecting rod bolts that secure the rod to the crankpin of the crankshaft. When a force is applied [by the piston and connecting rod] to the crankpin in any direction other than parallel or perpendicular through the centerline of the crankshaft, it causes the crankshaft to rotate. The engine manufacturer's parts catalogue shows that the crankshaft end of the connecting rod is comprised of the assembly (cap), bearing, bolt and nut to secure the bearing and cap to the crankpin.

The connecting rod cap and bolts from cylinder nos. 3 and 4 were submitted to the NTSB materials laboratory for examination. Examination of the parts using a scanning electron microscope revealed fatigue striations consistent with fatigue crack propagation on the fracture surface of one of the cylinder no. 4 cap remnants. The cracks were associated with a lack of or missing surface material, consistent with wear or spalling of the surface layer. A metallographic examination of the connecting rod cap showed cracks penetrating the surface, consistent with having initiated at the inner surface and having propagated into the cap material in an intergranular path. Multiple cracks were found oriented parallel to the surface and exhibited branching in multiple directions. The bolts had fractured from overstress, and three of the four nuts remained attached to their bolts. One of the nuts had fractured, but the examination could

not determine if the damage was consistent with post-fracture damage. Chemical analysis of the parts found that the connecting rod remnants were consistent with an alloy steel, but also found indications of lead and bromine. These elements were consistent with combustion products of brominated tetraethyllead additives in aviation fuel.

Materials laboratory examination of the crankshaft did not reveal any fractures or large cracks, or signs of gross plastic deformation with exception of some smearing on the cylinder 3 and cylinder 4 crankshaft journals.

A corresponding review of the engine data from an onboard engine monitoring instrument showed a brief, but continuous rise in oil temperature beginning at 0836:40 about 2 minutes before the data ceased, which was about the time of the accident. The data also showed an almost simultaneous and sudden decrease in EGT for cylinder nos. 1 and 4, with the cylinder no. 1 EGT's final recording at 0836:48. The oil temperature reached a peak of about 250° F at 0837:30, at which time the EGT values for the other two cylinders displayed sudden and extreme decreases.

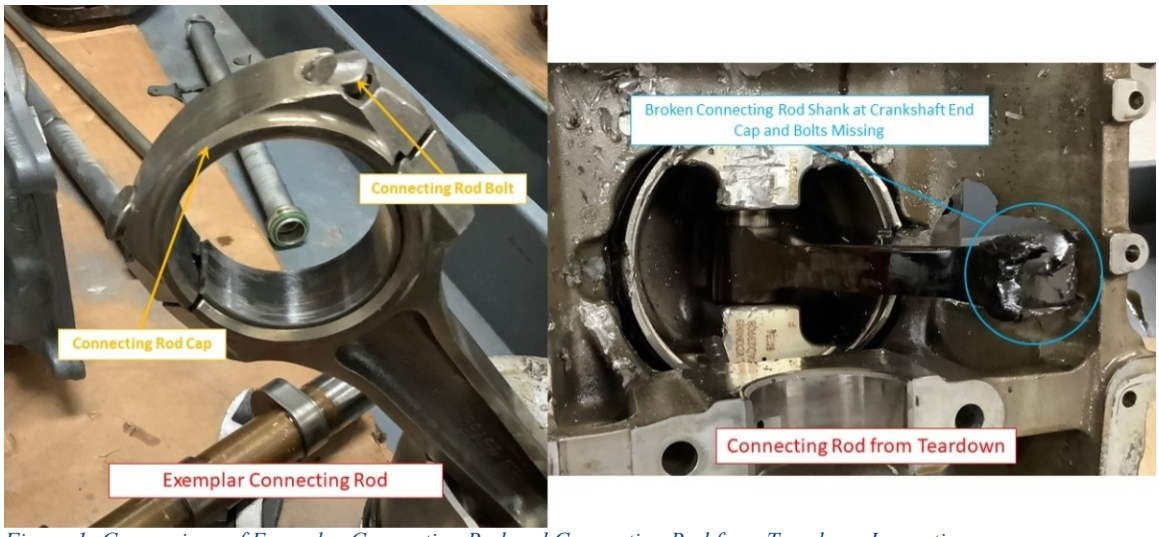

Figure 1: Comparison of Exemplar Connecting Rod and Connecting Rod from Teardown Inspection

Figure 2: Cylinder No. 3 and 4 Connecting Rod Caps and Bolts Retained from Teardown Inspection

A propeller examination revealed that the positions of the witness marks were consistent with low amounts of rotational absorption at the time of impact. The investigation did not find any evidence of a pre-impact mechanical failure with the propeller.

The propeller governor could not be functionally tested as it was partially seized due to the presence of debris and contaminants on the idler and drive gears. An NTSB materials laboratory chemical analysis revealed that some of the foreign material had compositions consistent with internal engine components. Further, the examination identified that the gasket was not a McCauley part and did not contain a filter at the oil inlet porthole to capture foreign debris.

The engine manufacturer reviewed photographs of the cylinder no. 3 and 4 connecting rod caps and bolts that were provided by the NTSB IIC. He identified evidence of thermal damage to the cylinder no. 3 and 4 connecting rod caps and bolts and some evidence of high heat at the crankshaft. He stated that this was evidence of an absence of lubrication and excessive heat.

Pilot Information

Certificate:	Commercial; Flight instructor	**Age:**	76,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	3-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane single-engine	**Toxicology Performed:**	No
Medical Certification:	BasicMed Waiver time limited special	**Last FAA Medical Exam:**	December 5, 2017
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	February 6, 2019
Flight Time:	3242 hours (Total, all aircraft), 3000 hours (Total, this make and model), 3116 hours (Pilot In Command, all aircraft), 8 hours (Last 90 days, all aircraft), 2 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Mooney	**Registration:**	N201HH
Model/Series:	M20J No Series	**Aircraft Category:**	Airplane
Year of Manufacture:	1976	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	24-0053
Landing Gear Type:	Retractable - Tricycle	**Seats:**	4
Date/Type of Last Inspection:	May 29, 2019 Annual	**Certified Max Gross Wt.:**	2740 lbs
Time Since Last Inspection:	27 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	4761 Hrs	**Engine Manufacturer:**	Lycoming
ELT:	C91 installed, not activated	**Engine Model/Series:**	IO-360-A3B6D
Registered Owner:	On file	**Rated Power:**	200 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	DVT,1478 ft msl	**Distance from Accident Site:**	
Observation Time:	08:53 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.91 inches Hg	**Temperature/Dew Point:**	22°C / 6°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Phoenix, AZ (DVT)	**Type of Flight Plan Filed:**	None
Destination:	Phoenix, AZ (DVT)	**Type of Clearance:**	VFR
Departure Time:	08:23 Local	**Type of Airspace:**	Class D

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	2 None	**Latitude, Longitude:**	33.685554,-112.065551

Administrative Information

Investigator In Charge (IIC):	Stein, Stephen
Additional Participating Persons:	Leon L Kelley; Federal Aviation FSDO; Scottsdale, AZ
Original Publish Date:	April 18, 2022
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=101272