



AVIATION



HIGHWAY



MARINE



RAILROAD



PIPELINE

Aviation Investigation Final Report

Location:	Creswell, Oregon	Accident Number:	WPR23LA184
Date & Time:	May 9, 2023, 17:50 Local	Registration:	N468MM
Aircraft:	RANS S-21	Aircraft Damage:	Substantial
Defining Event:	Loss of engine power (total)	Injuries:	1 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot had recently finished building the airplane and it had amassed about 55 hours of flight time on the airframe and engine. While the pilot was maneuvering at about 700-900 feet above ground level (agl), the engine made “rough” sounds and vibrated. About 20 seconds later the propeller seized and the pilot made a forced landing in the field below.

A postaccident examination of the engine revealed that the crankshaft was fractured at a crank cheek, just aft of the journal of the No. 2 connecting rod. A materials analysis revealed that the crankshaft fracture resulted from fatigue cracks originating at the surface of the aft radius on the No. 2 rod journal, likely due to high operating stresses on the fillet radii. The metallic particles in oil filters suggested continuous wear on the bearing shells. The worn bearing shells most likely intensified the high operating stress in the crankshaft. The source of the high operating stress acting on the crankshaft and severe wear of the bearings was not determined, but some out of range operating parameters recorded on the Engine Control Unit (ECU) could have contributed or been the source of these stresses, which led to fatigue cracks and severe wear of the bearing shells. Torque for the propeller flange was not measured, but the bolt, though not difficult to remove, likely lost preload torque due to the propeller striking the ground. There was no evidence that the crankshaft failure was a result of a material flaw or defect, and there is no discernible pattern, or recurring failures observed in the six-cylinder engine crankshafts.

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 caused by fatigue cracking and fracture of the crankshaft due to severe wear of the bearings.

Findings

Aircraft	Recip engine power section - Failure
Aircraft	Recip engine power section - Fatigue/wear/corrosion

Factual Information

History of Flight

Enroute-cruise	Loss of engine power (total) (Defining event)
Landing	Nose over/nose down

On May 09, 2023, about 1750 Pacific daylight time, a Rans S-21 homebuilt airplane, N468MM, was substantially damaged when it was involved in an accident near Creswell, Oregon. The pilot, the sole occupant, was not injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

The pilot and his son had recently finished building the airplane. The accident flight was one of a series of test flights the pilot was performing after making cowling modifications. After a normal departure, the pilot flew to a test area and was in flight for about 20 minutes. While the pilot was maneuvering at about 700-900 feet above ground level (agl), the engine made “rough” sounds and vibrated. About 20 seconds later, the propeller seized, and the pilot made a forced landing in the field below. During landing roll out, the airplane flipped over and came to rest inverted, damaging the vertical stabilizer (see Figure 1 below).



Figure 1: Wreckage

Pilot Information

Certificate:	Private	Age:	61, Male
Airplane Rating(s):	Single-engine land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	4-point
Instrument Rating(s):	None	Second Pilot Present:	No
Instructor Rating(s):	None	Toxicology Performed:	
Medical Certification:	Class 3 With waivers/limitations	Last FAA Medical Exam:	September 6, 2022
Occupational Pilot:	No	Last Flight Review or Equivalent:	March 16, 2022
Flight Time:	852 hours (Total, all aircraft), 55 hours (Total, this make and model), 800 hours (Pilot In Command, all aircraft), 65 hours (Last 90 days, all aircraft), 17 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	RANS	Registration:	N468MM
Model/Series:	S-21	Aircraft Category:	Airplane
Year of Manufacture:	2022	Amateur Built:	Yes
Airworthiness Certificate:	Experimental (Special)	Serial Number:	006180007
Landing Gear Type:	Tailwheel	Seats:	2
Date/Type of Last Inspection:	Continuous airworthiness	Certified Max Gross Wt.:	1800 lbs
Time Since Last Inspection:		Engines:	1 Reciprocating
Airframe Total Time:	54.6 Hrs at time of accident	Engine Manufacturer:	UL Power
ELT:	C126 installed, activated, did not aid in locating accident	Engine Model/Series:	520T
Registered Owner:	On file	Rated Power:	220
Operator:	On file	Operating Certificate(s) Held:	None

The UL Power 520T six-cylinder engine was new when installed on the airplane and had amassed a total time of about 55 hours. The pilot noted that for about the last 20 hours of engine operation, the engine monitoring unit showed that the cylinder head temperatures (CHT) in the Nos. 3 and 4 cylinders were high (occasionally the Nos. 2 and 6 cylinders would also be high). In response, the pilot changed to a larger oil cooler and was modifying the cowling to increase airflow.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	KEUG,373 ft msl	Distance from Accident Site:	15 Nautical Miles
Observation Time:	17:54 Local	Direction from Accident Site:	322°
Lowest Cloud Condition:	Few / 3500 ft AGL	Visibility	10 miles
Lowest Ceiling:		Visibility (RVR):	
Wind Speed/Gusts:	10 knots /	Turbulence Type Forecast/Actual:	None / None
Wind Direction:	360°	Turbulence Severity Forecast/Actual:	N/A / N/A
Altimeter Setting:	30.02 inches Hg	Temperature/Dew Point:	19°C / 8°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Creswell, OR	Type of Flight Plan Filed:	None
Destination:	Creswell, OR	Type of Clearance:	None
Departure Time:		Type of Airspace:	Unknown

Airport Information

Airport:	HOBBY FLD 77S	Runway Surface Type:	Asphalt
Airport Elevation:	541 ft msl	Runway Surface Condition:	Dry
Runway Used:	16/34	IFR Approach:	None
Runway Length/Width:	3102 ft / 60 ft	VFR Approach/Landing:	None

Wreckage and Impact Information

Crew Injuries:	1 None	Aircraft Damage:	Substantial
Passenger Injuries:	N/A	Aircraft Fire:	None
Ground Injuries:		Aircraft Explosion:	None
Total Injuries:	1 None	Latitude, Longitude:	43.938882,-123.00586(est)

Tests and Research

Investigators conducted a postaccident examination of the wreckage, which included a complete disassembly of the engine. The cowlings had been removed and a trace amount of oil on the bottom cowlings was noted in the area under the Nos. 2, 4, and 6 cylinders. Removal of the top spark plugs revealed that all showed signatures that the engine representative stated were consistent with normal operation.

Investigators were unable to rotate the crankshaft by hand using the propeller; it would only rotate a few degrees before binding. Clean, uncontaminated oil was observed at all six rocker box areas. Removal of the cylinders revealed that the combustion chambers and pistons were undamaged. Removal of the oil sump drain revealed that the magnetic plug was full with ferrous metal; metal pieces were also found in the oil sump. The oil pump was disassembled and there was limited metal found inside, with the exception of the bypass spring.

Upon applying force to the propeller, the engine would not rotate through. Removal of the pistons revealed that the crankshaft was fractured at a web (crank cheek), just aft of the No. 2 connecting rod journal. The thrust bearing mount was able to move forward and aft.

Disassembly of the crankcase revealed that the six connecting rod journals still had their respective rods and caps attached; all were able to be easily rotated about their respective journals (see Figure 2 below).

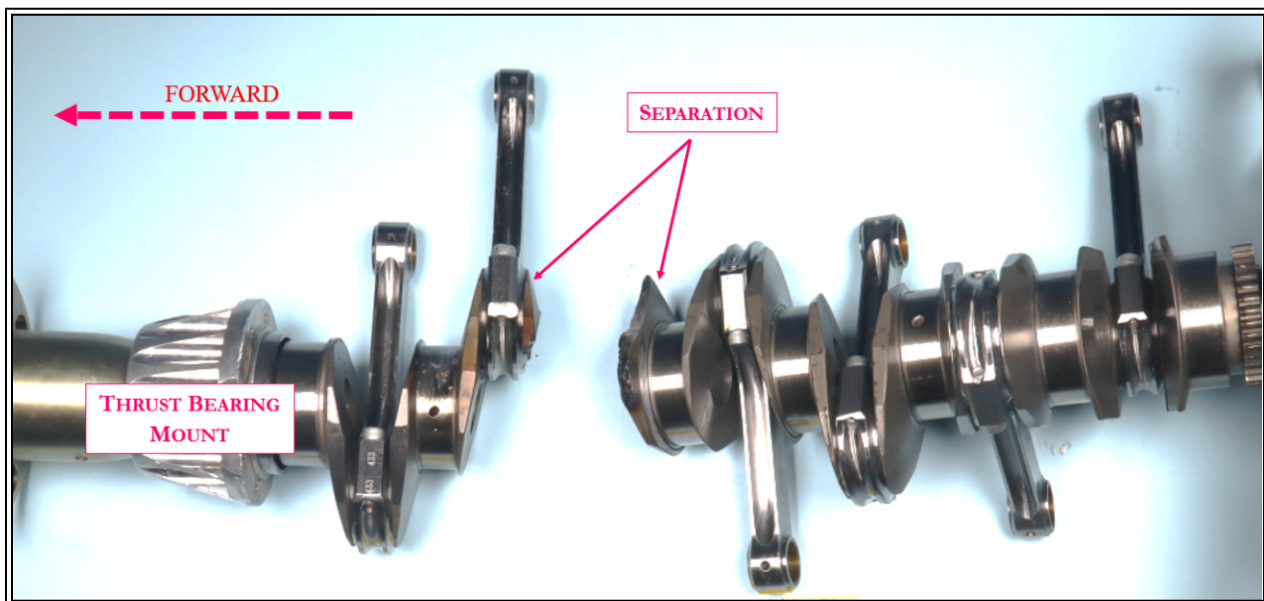


Figure 2: Crankshaft

The fracture extended through the crank cheek in the area between the No. 2 rod journal and the No. 3 main journal. The fracture surface was relatively shiny and reflective, with a portion of the cheek showing severe deformation damage and heat tinting on the forward face. The preliminary assessment of the fracture surfaces was consistent with a fatigue fracture at the aft radius of the No. 2 rod journal (see Figure 3 below).

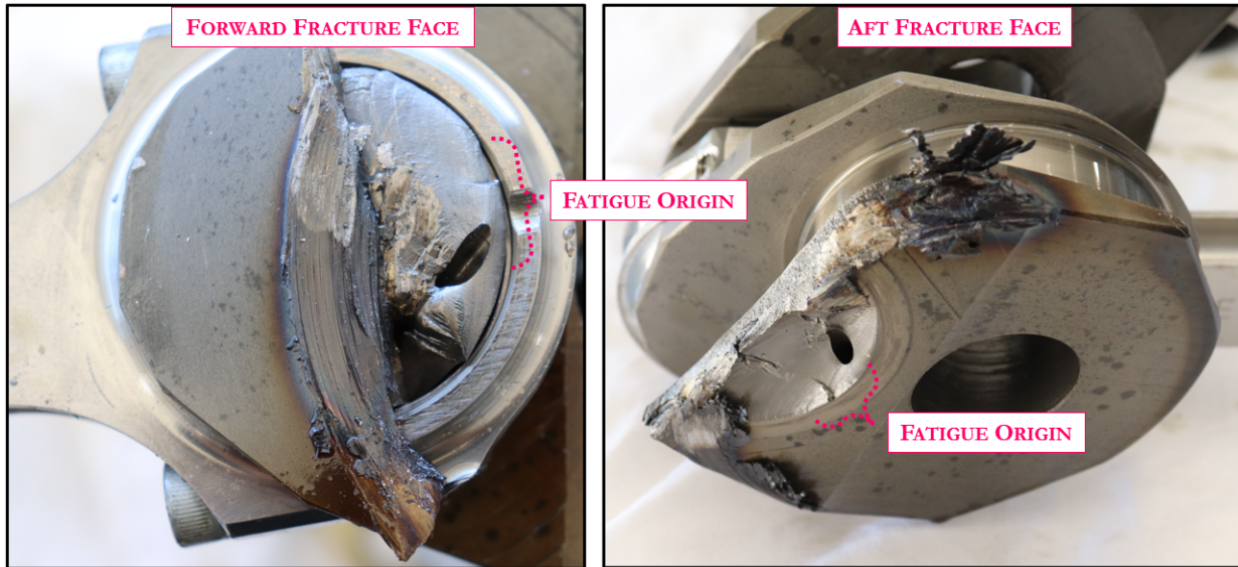


Figure 3: Mating Fracture Faces

The National Transportation Safety Board Materials Laboratory examined the engine crankcase, crankshaft with attached connecting rods and bearings, seven pairs of main bearing halves, two filters, and sectioned oil tube.

The No. 2 rod journal's aft fracture face displayed crack arrest marks consistent with fatigue cracking, originating from multiple points at the surface of the aft radius. Circumferential scoring marks were present on the surface of the aft radius, intersecting the fatigue origin area, with the fatigue crack measuring about 1.6 inches. The crack propagated through 30% of the rod journal cross section. The remaining fracture extended axially through the crank cheek between the No. 2 rod journal and the No. 3 main journal. The major portion of the crank cheek fracture exhibited damage consistent with post-fracture mechanical damage. The mating fracture exhibited similar fracture features.

Evidence of superficial cracks at the radii locations was observed in the No. 1 main journal, No. 1 rod journal, No. 2 main journal, and No. 2 rod journal. The remainder of the crankshaft revealed no evidence of cracks at the radii locations.

The bearing shell halves for the No. 2 main journal at the inner surface showed evidence of severe circumferential scoring that exposed the steel core layer, and the inner layers of copper, aluminum, lead, and tin, whereas the inner surface of the remaining main journal bearings showed evidence of moderate circumferential scoring. Examination of two oil filters (one oil filter was mounted on the engine at the time of the incident; the other oil filter was replaced during the last oil change) revealed that the accordion-like fabric section contained material embedded within them. SEM examination of the exterior surfaces of both fabric portions indicated the presence of metallic particles. Analysis using a handheld alloy analyzer detected metal particles containing aluminum, lead, copper, iron, zinc, nickel, molybdenum, and chromium in varying proportions, consistent with metal from the crankshaft bearing shells.

The sizes of the thrust bearing disc springs were measured and found to be within specification and no wear or damage was detected.

The specified torque for the propeller flange bolt was 221 foot-pounds (ft-lbs) and it had not been removed since its initial installation. Disassembly of the propeller flange bolt with a wrench revealed that the bolt required less rotational torque to remove than expected and the threads from the disassembled bolt showed no signs of mechanical damage. It was not possible to check the propeller balance due to damage incurred after impact.

The postaccident download of the ECU revealed that the turbocharger pressure and fuel pressure were below operational limits, which the engine manufacturer stated would have resulted in a leaner mixture. In addition, the wide-open throttle RPM was, in certain moments of the flight, below operational limits, which the engine manufacturer stated would result in additional stresses on the piston/crankshaft.

Administrative Information

Investigator In Charge (IIC):	Keliher, Zoe
Additional Participating Persons:	Greg Howard; Federal Aviation Administration; Hillsboro, OR
Original Publish Date:	May 14, 2024
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=130455

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