RNSA

Rannsóknarnefnd samgönguslysa

Report on aircraft serious incident

Case no: **M-01913/AIG-14**

Date: **20. October 2013**

Location: **Northeast of Geysir in Haukadalur**

Description: **Loss of engine power**

Investigation per Icelandic Law on Transportation Accident Investigation, No. 18/2013 shall solely be used to determine the cause(s) and contributing factor(s) for transportation accidents and incidents, but not determine or divide blame or responsibility, to prevent further occurrences of similar cause(s). This report shall not be used as evidence in court and it shall not be used to determine or divide blame or responsibility.

1. FACTUAL INFORMATION

Location and time	
Location:	On Road 35, about 2 km northeast of Geysir in Haukadalur, Southern Iceland (64°18‘ 48.60“ N and 020°17‘ 26.49“ W)
Date:	October 20th 2013
Time[1]:	11:42

Aircraft	
Type:	Diamond DA-40
Registration:	TF-KFD, registered as a flight trainer
Year of manufacture:	2008
Serial number:	D4.371
Engine:	One diesel powered TAE 125-02-99 engine
CoA[2]:	Valid

Other information	
Type of flight:	Private
Persons on board:	Two
Injuries:	None
Damage to aircraft:	Minor
Short description:	The airplane lost engine power and an emergency landing was made
Weather:	Temperature 2°C, wind 030/5 knots

Pilot	
Age:	28 year old
License:	Holder of a valid PPL[3] issued by the Icelandic Civil Aviation Administration[4]
Ratings:	SEP[5]
Medical certificate:	First class, valid
Flight experience:	Total hours: 77.1 flight hours Total hours on type: 10 flight hours Last 90 days: 4.5 flight hours Last 24 hours: 2.5 flight hours

[1] All times in the report are UTC and where applicable local times are shown in ( )
[2] Certificate of Airworthiness
[3] Private Pilot Licence
[4] Now Icelandic Transportation Authority
[5] SE piston (land)

At 10:36 AM on October 20th 2013 a pilot and one passenger took off from Keflavik Airport (BIKF) in airplane TF-KFD, for a planned 2.5 hour cross country flight around the southern part of Iceland. Before the flight the pilot had performed a pre-flight check on the airplane and performed weight and balance calculations. The purpose of the flight was to build flight hours towards a commercial pilot license.

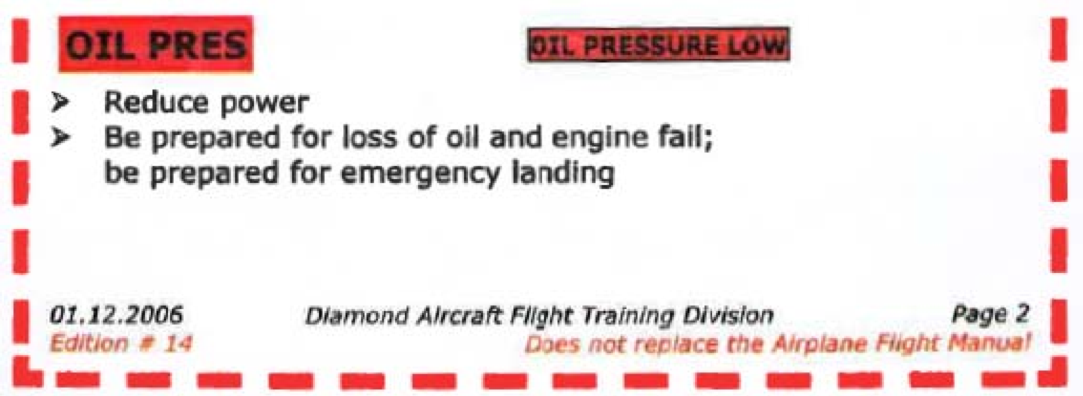
At 11:42, while cruising between Gullfoss and Geysir, in Southern Iceland, at an altitude of 3000-3500 feet[6], the engine suddenly started running roughly, and did so for about 5 seconds. During this rough engine run, the pilot scanned his instruments and noticed an oil pressure warning light and heard an audio warning. The pilot noticed on the engine instrument section of the flat display panel that the oil pressure had dropped and that the engine power load[7] was rapidly dropping from its 70% power configuration, down to 0% and the propeller started to windmill. A red X then appeared over engine load and RPM on the engine instruments, confirming loss of engine power. See Figure 1.

Figure 1: Red X over engine load and RPM on the instruments in the top left corner

[6] MSL

[7] The engine LOAD is not measured, but calculated by the ECU from common rail fuel pressure, ECU commanded injection time, manifold pressure and prop RPM

The pilot moved the throttle to idle and then back to full power, without any changes in the instruments. The pilot then switched the ECU[8] between channels A and B. No change was observed. The Emergency Procedures[9] for low oil pressure were referred to, which stated the following as shown in Figure 2.


OIL PRES
OIL PRESSURE LOW

- Reduce power
- Be prepared for loss of oil and engine fail; be prepared for emergency landing

01.12.2006 Diamond Aircraft Flight Training Division Page 2
Edition # 14 Does not replace the Airplane Flight Manual!

Figure 2: Emergency procedures for low oil pressure

The emergency landing checklist was referred to and completed. The pilot altered the airplane's pitch so it would fly at 68 knots[10]. He then looked for a suitable place for emergency landing, while declaring an emergency on frequency 121.5 MHz.

When the airplane lost engine power it was flying southwest along Road 35, which lies between Gullfoss and Geysir. The pilot decided to turn 180° and perform an emergency landing on the road towards the northeast. According to the pilot, there were several reasons for his decision:

- There was no traffic on the road
- They were already getting close to Geysir and had just passed a straight part of the road leading towards northeast
- The road slopes upwards towards the northeast
- The wind was from the northeast
- He would not be blinded by the sun when landing towards northeast
- He was aware of a grass field next to the road, but because it looked a bit un-even he deemed it as a secondary choice when compared to the road

[8] Engine Control Unit, which includes FADEC and Engine Data Monitoring System
[9] DA40 TDI Garmin 1000, issued 1.12.2006, Page 2
[10] Optimum glide speed for Diamond DA-40

During the descent the pilot had not heard a reply to his emergency call on frequency 121.5 MHz[11]. When on base leg, the pilot repeated his emergency call and was answered by the flight crew of an international commercial flight passing over Iceland, which relayed the emergency call to Reykjavik Control[12].

Shortly before landing the pilot fully extended the flaps of the airplane. When the flaps went down to its fully extended position the speed fell below 60 knots. The pilot then corrected by pitching the airplane further down to increase the speed closer to the optimum gliding speed (68 knots). As a result the airplane lost more altitude than the pilot had expected and he had to pull back the elevator control shortly before landing, resulting in the airplane bouncing once on the road before making a firm landing.

The pilot and the passenger had no problem exiting the airplane. As they had landed on a road, they decided to move the airplane so only one of the road's lanes would be blocked. See Figure 3.

Figure 3: The location of the incident airplane upon arrival of ITSB investigator

[11] It should be noted that ATC does not monitor the Emergency frequency, except around controlled aerodromes
[12] Air Traffic Control

After the landing the pilot and the passenger noticed engine oil on the nose landing gear strut as well as on the road. See Figure 4.

Figure 4: Oil leakage on site

The ITSB[13] was informed of the incident via telephone by both the Emergency Services[14] and Reykjavik Control and an aircraft accident investigator was dispatched to the site.

The engine cowlings were removed. Engine oil was found on the lower engine cowling. The V-ribbed belt drive connecting the alternator and other components to the engine‘s crankshaft was found out of position. See Figure 5.

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[13] Icelandic Transportation Safety Board (Rannsóknarnefnd samgönguslysa, or RNSA, in Icelandic)

[14] Neyðarlínan, 112

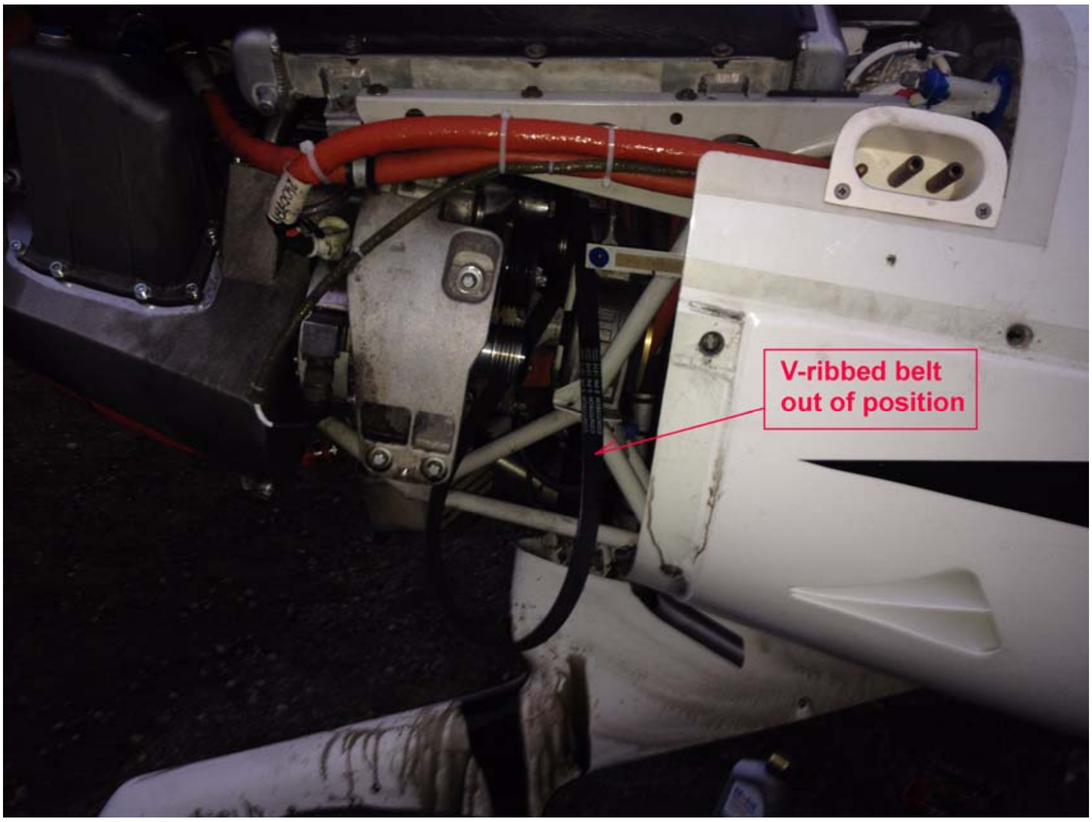

Figure 5: V-ribbed belt out of position

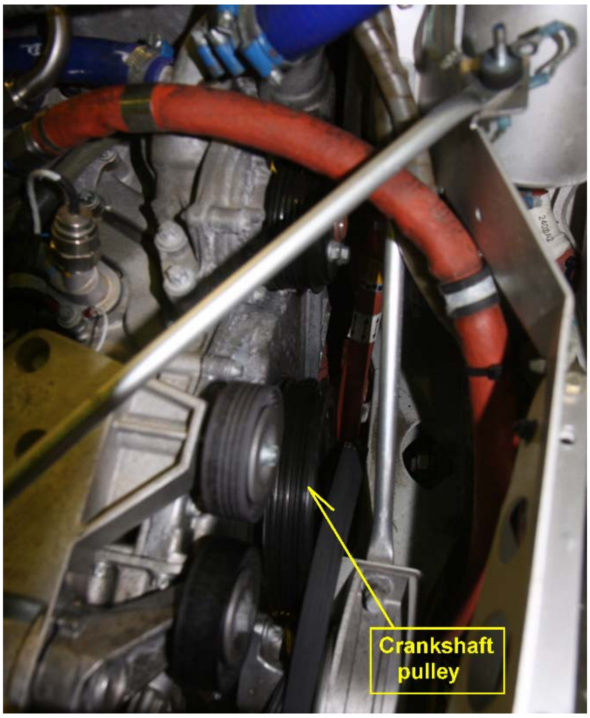

Figure 6: Crankshaft pulley skewed out of position

Further inspection revealed that the V-ribbed belt pulley for the crankshaft was skewed out of position. See Figure 6.

The engine and the ECU were removed from the airplane and sent to the manufacturer, Technify Motors in Germany, for detailed analysis. There the engine was disassembled and analyzed along with the ECU, under the supervision of investigators from the ITSB and the BFU[15].

[15] Bundesstelle für Flugunfalluntersuchungen (Germany)

2. ANALYSIS AND CONCLUSION

The investigation of the engine system data monitoring system showed that the oil pressure dropped to zero bars at the time of the incident and then the engine RPM had slowed down to propeller windmilling.

The engine had accumulated over 1244 flight hours since installation. The tear down inspection of the engine revealed extensive damage that was caused by a missing fastener P/N 05-7223-K000501 that attaches the crankshaft's pulley. See Figure 7 for details. This fastener was never found.

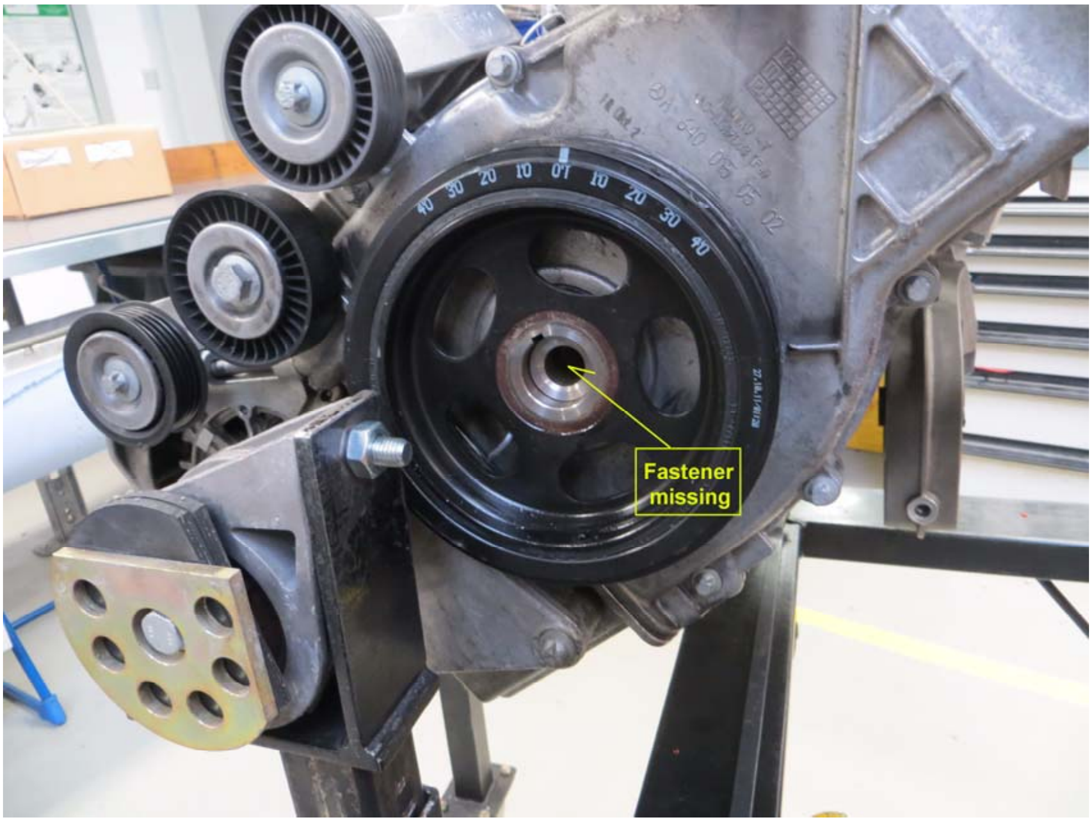

Figure 7: Missing the fastener that attaches the belt pulley to the crankshaft

Due to the missing fastener, the belt pulley had moved on the crankshaft and was skewed out of position. This allowed abnormal loading to be put on the crankshaft as it turned. The belt pulley has a torsional damper around its inner area. The purpose of this torsional damper is to act as a dampener for belt pulley vibration. According to the manufacturer, the pulley is also designed to damp the crankshaft vibrations (flexible mode) or to move the modes into non-critical ranges. The crankshaft is usually balanced with the pulley together and therefore the position of the pulley is important and defined by the feather key. The damping only works if there is a tight connection assured by the bolt. If the bolt gets lose the dampening effect will get lost. Without the absorption of the flexible mode the bending of the crankshaft is higher and causes a higher load to the journals close to the pulley. See Figure 8 for details.

Figure 8: Torsional damper on crankshaft belt pulley

When the crankshaft fastener was no longer in its place and the belt pulley was skewed out of position, this caused significant wear of the bearing halves. Due to the heavy load some of the debris blocked the lubrication bores causing a lack of lubrication with consequently overheating. The oil supply hole in the upper half of the crankshaft bearing closest to the belt pulley was found completely closed by wear damage. This prevented circulation of oil from the oil pump to the crankshaft area of the engine. This process supported the seizure, but the crankshaft fracture is a believed to have been the consequence of the lack vibration absorption by the torsional damper. See Figure 9 and Figure 10 for details.

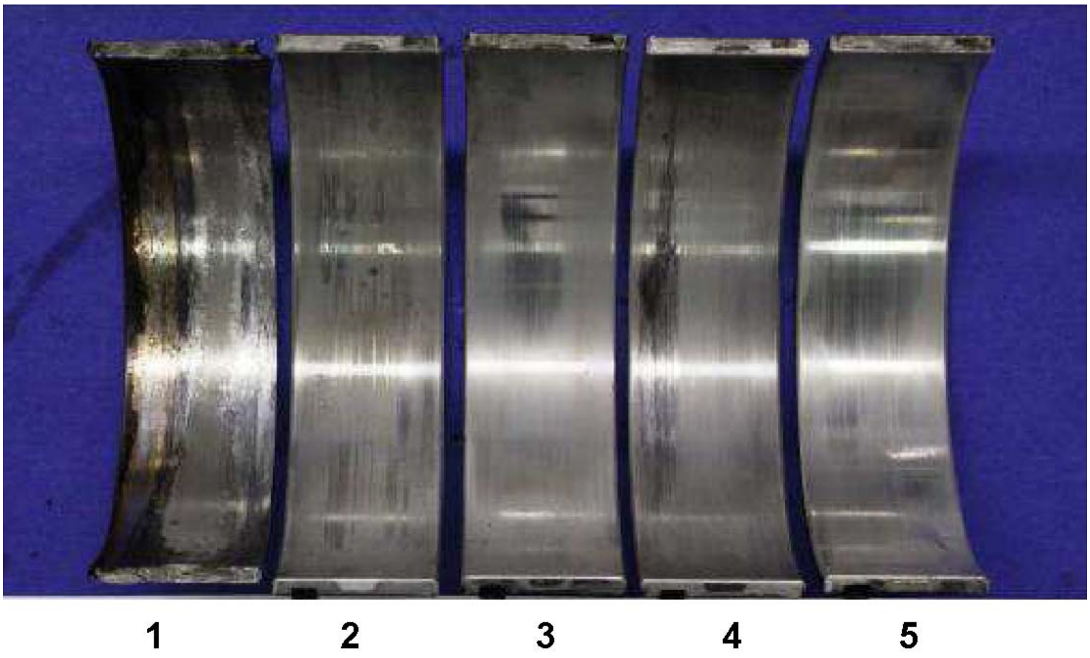

Figure 9: Lower crankshaft bearings (1 is the position closest to the belt pulley)

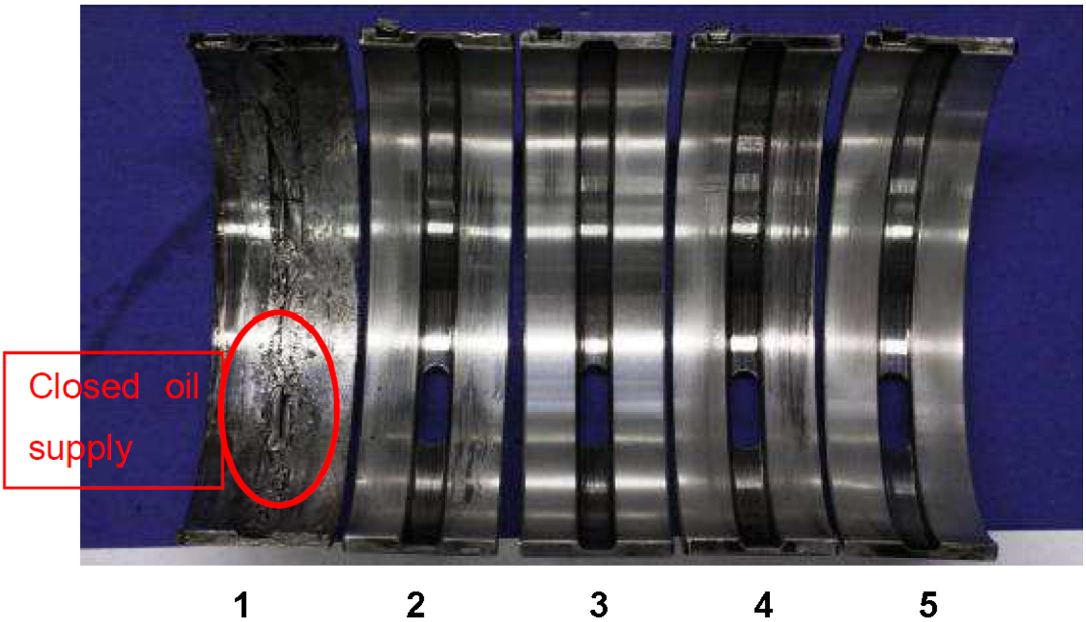

Figure 10: Upper crankshaft bearings (1 is the position closest to the belt pulley)

Inspection of the crankshaft area, aft of the closed oil supply hole, revealed elevated temperature indications of the crankshaft, as the crankshaft was found discolored in that area. In the same area the crankshaft was found fractured. See Figure 11 for details.

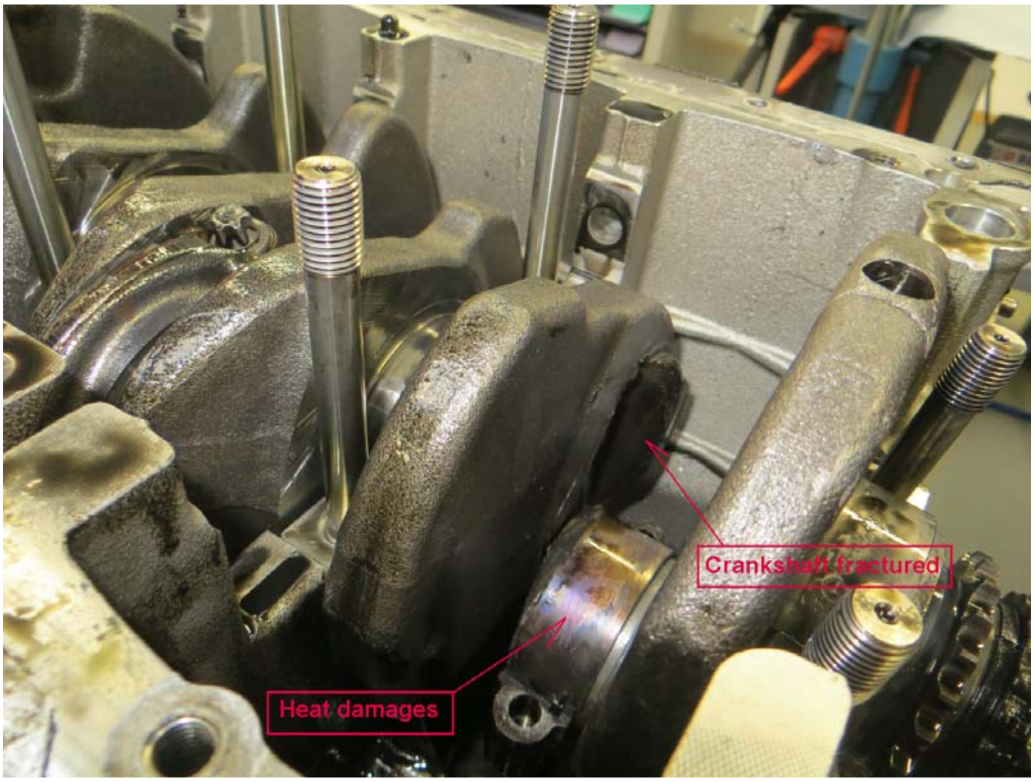

Figure 11: Crankshaft fractured and heat damages

The crankshaft was analyzed around the fracture surface. Scratches were found on the crankshaft at the position of crankshaft bearing 2. See Figure 12.

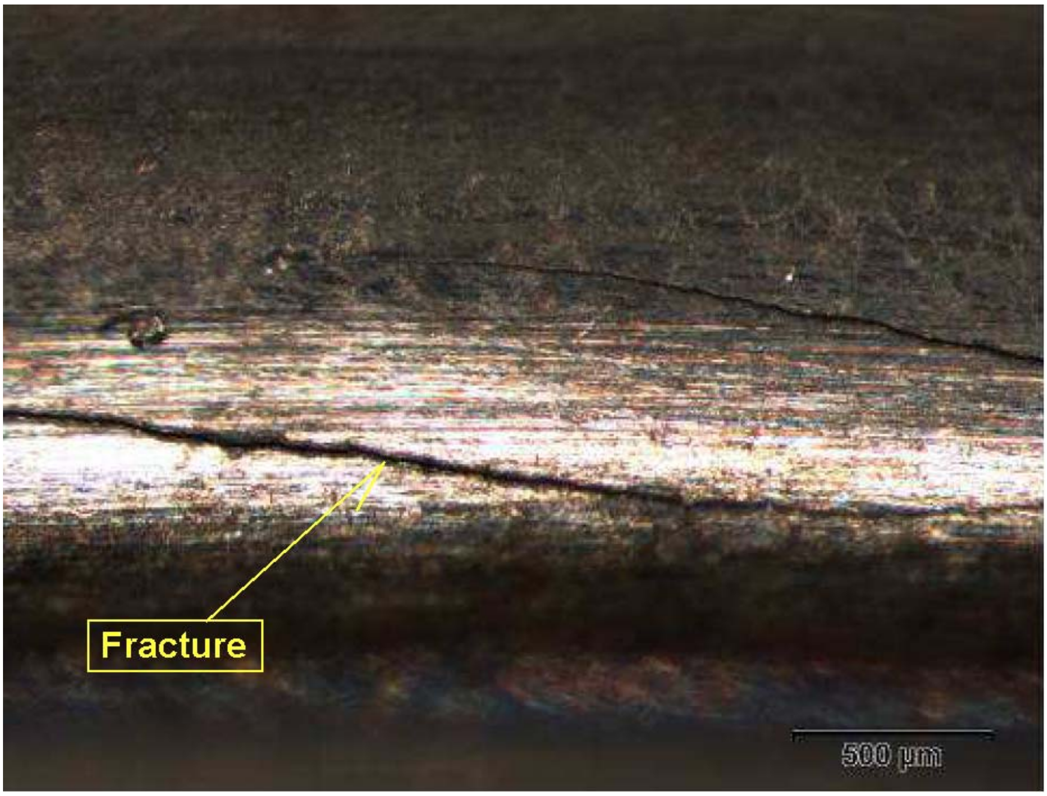

Figure 12: Scratches on crankshaft surface around fracture located at bearing 2

Analysis of the crankshaft fracture revealed crack initiation in the area where scratches were found on the crankshaft surface as well as indications of tempering colors. See circle #1 in Figure 13. The crack then grew through the crankshaft with striations lines (indications of fatigue) being apparent in the middle section. See circle #2 in Figure 13. At the opposite end of the crankshaft's cross section, material analyses showed the fracture surface to change from a fatigue crack to a forced fracture break. At this point the crankshaft could no longer support the loading it was subjected to and it broke. See circle 3 on Figure 13.

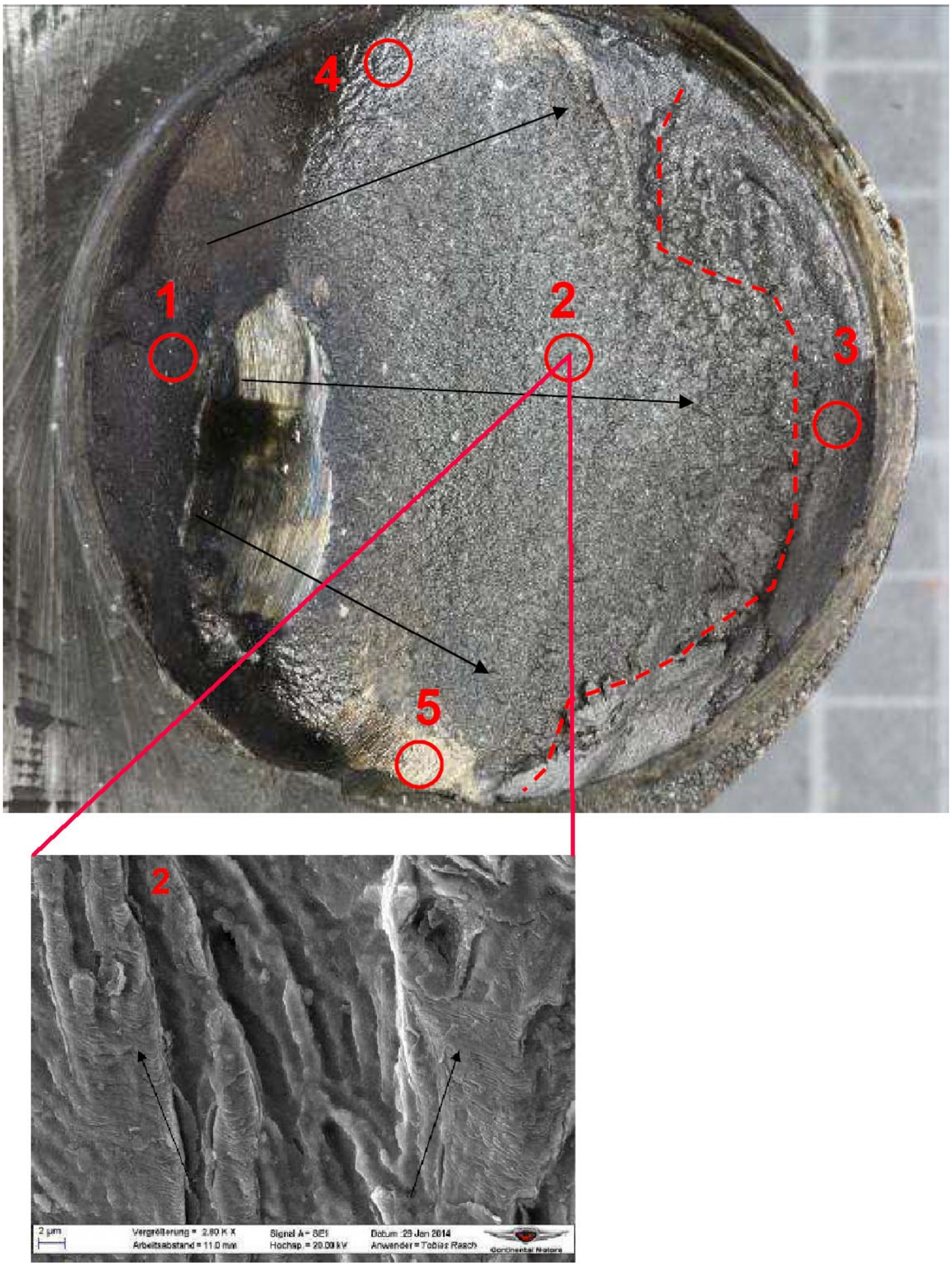

Figure 13: Crankshaft fracture at timing chain side

The fracture of the crankshaft then lead to multiple secondary damages, such as fracture of the engine bed plate, crank case housing and the oil pump.

The ITSB investigated if the belt pulley fastener had been installed using the correct torque value during the engine assembly. According to the manufacturer, the torque value for this bolt is 200 Nm + 90°, with a final torque requirement between 210 Nm and 395 Nm. The manufacturer's task cards from the engine's assembly were retrieved during the investigation. Per the yellow highlighted lines in Figure 14 the task cards show a correct torque procedures, with a final torque value of 350.10 Nm.

			963	
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		Wert	Min	Max
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	STROM	50.30	5.00	70.00
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Figure 14: The highlighted data is the installation of the belt pulley fastener

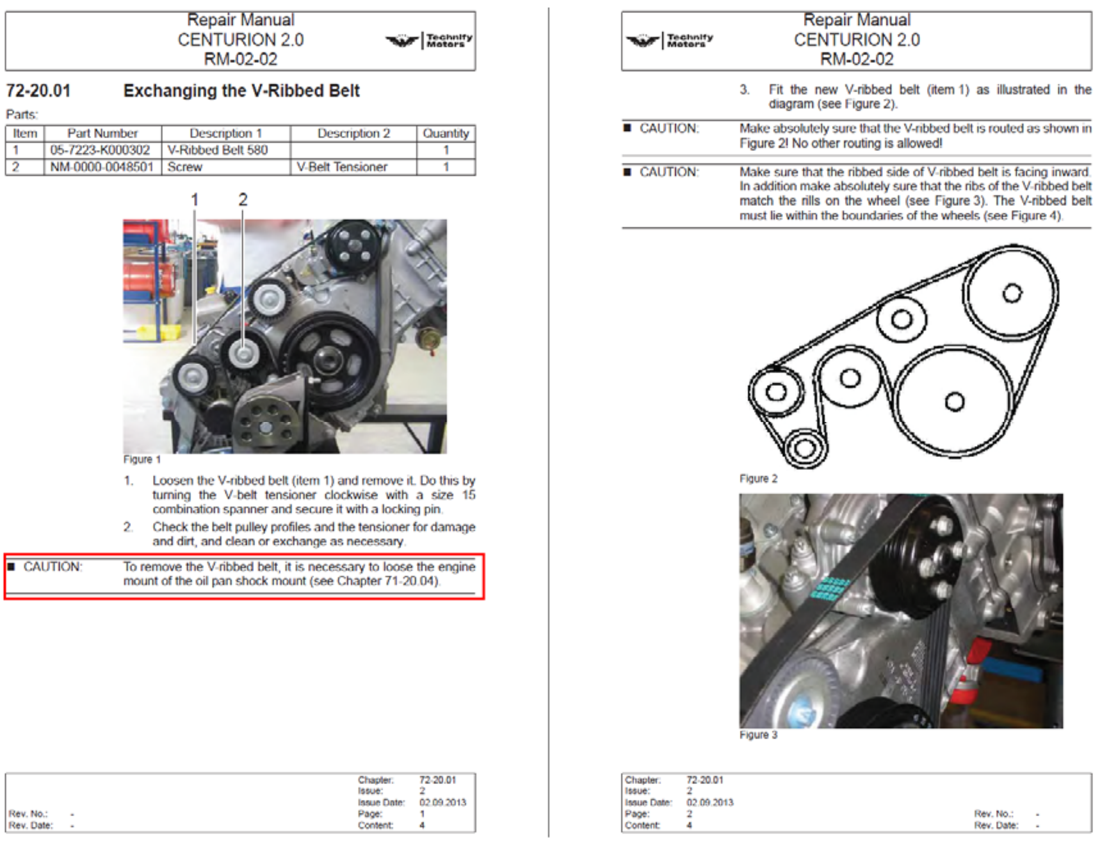
During the engine's teardown inspection the ITSB looked for evidence of fastener P/N 05-7223-K000501 failure, such as a missing fastener head while the shank still in place or damaged threads in the fastener hole. No part of the fastener was found imbedded in the fastener hole. The fastener hole was cut-away to allow the threads to be analyzed for any fastener failure indication. The threads showed no sign of damage. See Figure 15 for details.

Figure 15: No damages found to fastener hole threads

The investigation revealed that no re-torque value is provided in the engine's maintenance manual for the fastener found missing. When the manufacturer was asked about this, he stated that it was deliberate as the correct torque on this bolt was both critical and very high. It was not included in the in-field engine's maintenance manuals provided to the operators, as it was only to be re-torqued during overhaul under strict quality control measuring.

The last maintenance on the aircraft was performed on October 14th 2013, six days and 21.4 flight hours prior to the serious incident. At this time, the engine had accumulated 1222.6[16] flight hours since installation. Technify Motors Operation & Maintenance Manual OM-02-02, chapter 5.1.4, states that this V-ribbed belt is to be replaced every 1200 operating hours and a reference is made to RM-02-02, chapter 72-20.01 for the replacement instructions. According to a component change records sheet in this work package, this maintenance included a replacement of the V-ribbed belt P/N 05-7223-K000302 that was found out of position during the serious incident. The work package due list details that the V-ribbed belt was replaced per work order 1425069 in accordance with Technify Motors Operation & Maintenance Manual OM-02-02.

According to RM-02-02, chapter 72-20.01, the replacement instructions for the V-ribbed belt is such that the engine mount of the oil pan shock mount has to be loosened to allow replacement of the V-ribbed belt to be accomplished, due to a very tight fit in this area. See the red boxed CAUTION note on Figure 16 for details and explanations on Figure 17.


Repair Manual
CENTURION 2.0
RM-02-02

72-20.01 Exchanging the V-Ribbed Belt

Parts:

Item	Part Number	Description 1	Description 2	Quantity
1	05-7223-K000302	V-Ribbed Belt 580		1
2	NM-0000-0048501	Screw	V-Belt Tensioner	1

Figure 1

1. Loosen the V-ribbed belt (item 1) and remove it. Do this by turning the V-belt tensioner clockwise with a size 15 combination spanner and secure it with a locking pin.
2. Check the belt pulley profiles and the tensioner for damage and dirt, and clean or exchange as necessary.

CAUTION: To remove the V-ribbed belt, it is necessary to loose the engine mount of the oil pan shock mount (see Chapter 71-20.04).

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3. Fit the new V-ribbed belt (item 1) as illustrated in the diagram (see Figure 2).

CAUTION: Make absolutely sure that the V-ribbed belt is routed as shown in Figure 2! No other routing is allowed!

CAUTION: Make sure that the ribbed side of V-ribbed belt is facing inward. In addition make absolutely sure that the ribs of the V-ribbed belt match the rills on the wheel (see Figure 3). The V-ribbed belt must lie within the boundaries of the wheels (see Figure 4).

Figure 2

Figure 3

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Figure 16: Manufacturer‘s replacement instructions for the V-ribbed belt

[16] 1244 FH – 21.4 FH = 1222.6 FH

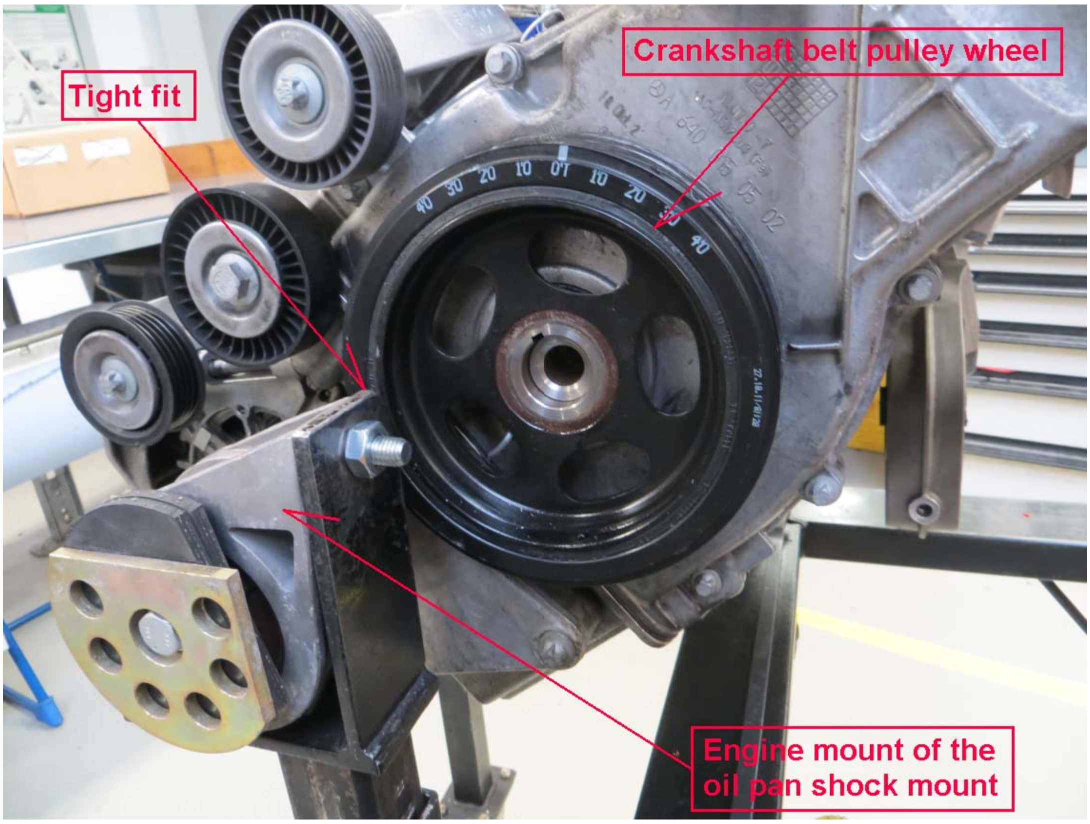

Figure 17: Tight fit for V-ribbed belt replacement

The ITSB was not able to determine why the missing bolt became loose.

Actions already taken as a result of this incident

After this serious incident the manufacturer changed RM-02-02 chapter 72-20.01 and added a caution that crankshaft belt pulley fastener P/N 05-7223-K000501 shall only be turned counterclockwise.

Probable Cause(s):

- The crankshaft belt pulley fastener became loose

Contributing factors:

- When the belt pulley loosened, its damper ring instead of being a damper started causing oscillating vibration motion of the crankshaft
- This caused the crankshaft to hammer against the outermost lower crankshaft bearing, causing its oil supply hole to close
- The closed oil supply hole caused elevated temperature of the crankshaft, which in combination with the oscillating motion caused fatigue crack to generate
- The fatigue crack grew due to the high RPM of the engine crankshaft
- Failure of the crankshaft occurred when the loading through the crankshaft could no longer be supported by the remaining cross sectional material of the crankshaft at the crack location
- Failure of the engine occurred when the crankshaft broke
- Secondary damages, such as to the engine bed plate, crank case housing and oil pump occurred as a result of the crankshaft failing at high RPM

3. SAFETY RECOMMENDATIONS

Technify Motors:

- Issue a service letter to operators, advising of this incident and remind them never to loosen the belt pulley fastener in the crankshaft, due to its critical torque value
- Reconsider the design of the crankshaft belt pulley fastener P/N 05-7223-K000501 in order to prevent loosening of the fastener

The following board members approved the report:

- Geirþrúður Alfreðsdóttir, chairman
- Bryndís Lára Torfadóttir, board member
- Gestur Gunnarsson, board member

Reykjavik, 6. August 2015

The Icelandic Transportation Safety Board