AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/8533		
Aircraft Registration	**ZS-RMA**	**Date of Accident**	15 August 2008		**Time of Accident**	1010Z	
Type of Aircraft	Beechcraft F33A		**Type of Operation**		Private		
Pilot-in-command Licence Type		Private	**Age**	27	**Licence Valid**	Yes	
Pilot-in-command Flying Experience		Total Flying Hours	436.7		Hours on Type	268.3	
Last point of departure	Tzaneen Aerodrome (FATZ) – Limpopo Province						
Next point of intended landing	Tzaneen Aerodrome (FATZ) – Limpopo Province						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
At Appelfontein farm near Dendron, GPS Position: S23°23.296′; E029°11.743′, Elev = 3397ft							
Meteorological Information	Surface wind, 020°/5kt, Temperature, 28°C, Visibility, CAVOK.						
Number of people on board	1+1	**No. of people injured**	0	**No. of people killed**	0		

Synopsis

The aircraft was participating in an air race (Race of Champions) which commenced from Tzaneen Aerodrome (FATZ) and was to end at FATZ. Approximately an hour and ten minutes into the race, flying between Marble Hall and Vivo, the pilot experienced a sudden loss of engine power, the engine started spluttering and failed. The pilot spotted an open field on a farm (Appelfontein) and decided to execute a forced landing which led to the aircraft sustaining substantial damage. The occupants of the aircraft did not sustain any injuries.

During the engine examination it was established that the engine had lost power and failed because the camshaft drive and idler gears failed. The gears failed as a result of metal fatigue and the fact that the root radii on the cam drive gear were smaller than those on the idler gear. Given the extent of the internal damage to the engine, the pilot would have been unable to restart the engine. This left the pilot with only one option, to attempt an emergency landing without engine power.

Probable Cause

Unsuccessful forced landing as a result of loss of engine power followed by an engine failure.

Contributory factor/s

Failure of the camshaft drive and idler gears.
Metal fatigue

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator	: Dotcom Trading 398 (PTY) LTD
Manufacturer	: Beech Aircraft Corporation
Model	: F33A
Nationality	: South African
Registration Marks	: ZS-RMA
Place	: Farm Appelfontein near Dendron
Date	: 15 August 2008
Time	: 1010Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation :

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer:

This report is given without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of flight

1.1.1 On 15 August 2008 the aircraft with two occupants on board was participating in an air race (Race of Champions) from Tzaneen Aerodrome. The aircraft was flying a particular set course (track points) and was supposed to return to Tzaneen Aerodrome.

1.1.2 Approximately an hour and ten minutes into the race, flying between Marble Hall and Vivo, the pilot experienced a sudden loss of engine power, the engine started spluttering and failed. The pilot did not attempt to restart the engine, but chose to land as soon as he could.

1.1.3. The pilot spotted an open field on a farm (Appelfontein) and decided to execute a forced landing. While attempting to land, the aircraft impacted a one-metre high ridge at high speed which caused it to bounce. The pilot then lost control. The aircraft impacted the ground at high speed and struck several thorn bushes before it came to an eventual stop.

1.1.4. During the accident sequence, the aircraft sustained substantial damage to the right wing and flaps, as well as the propeller, which made contact with the ground. The nose and the right main landing gear also broke off on impact with the ground.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	1	1	-	-

1.3 Damage to aircraft

1.3.1 The aircraft was substantially damaged.

Picture 1: A View of the damaged aircraft

1.4 Other damage

1.4.1 No other damage was caused.

1.5 Personnel Information

1.5.1. Pilot-in-command

Nationality	South African	Gender	Male	Age	27
Licence Number	***************	Licence Type	Private		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Night				
Medical Expiry Date	31 July 2010				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	436.7
Total Past 90 Days	21.4
Total on Type Past 90 Days	21.4
Total on Type	268.3

1.5.2. Navigator

1.5.2.1. The other occupant of the aircraft was also a pilot rated on this type of aircraft and was not involved in the flying of the aircraft, but was purely there as a navigator for the race.

1.6 Aircraft information

Airframe:

Type	Beechcraft F33A	
Serial Number	CE-528	
Manufacturer	Beech Aircraft Corporation	
Year of Manufacture	1975	
Total Airframe Hours (At time of Accident)	4129.15	
Last MPI (Date & Hours)	15 May 2008	4113.95
Hours since Last MPI	15.2	
C of A (Issue Date)	02 October 1974	
C of R (Issue Date) (Present owner)	27 May 2008	
Operating Categories	Standard	

Engine :

Type	Continental I0-520
Serial Number	822795-R
Hours since New	395.05
Hours since Overhaul	TBO not yet reached

Note: According to available records from the engine logbook, this engine was rebuilt and zero-timed on 24 August 2001 by Teledyne Continental Motors in accordance with an FAA approved Quality Control System, using FAA approved engineering design data and the applicable requirements of FAR Part 21 of the Federal Aviation Regulations. The engine logbook indicates that the most recent MPI was completed on the aircraft on 15 May 2008 at 393.05 engine hours and 4113.95 airframe hours.

1.6.1. The investigator in charge (IIC) contacted the manufacturer of the engine through the National Transportation Safety Board of the United States of America (NSTB), in an attempt to obtain information relating to the traceability of the gears, and the manufacturer stated the following:

- “This would have been a new camshaft and idler gear.”

- “There are no batch records available on these gears.”

- “The gears would have been manufactured by an outside vendor, not by Teledyne Continental Motors.”

Propeller:

Type	McCauley 3A32C76
Serial Number	743121
Hours since New	102.25
Hours since Overhaul	TBO not yet reached

1.7 Meteorological Information

1.7.1 The weather information obtained from the South African Weather Services states:

A high pressure system was east of the country, ridging in over the far northeastern part of the country. Over the southern part of the county a cold front was present with a low south of the country. Wind in the Dendron area was light north-easterly and there was no cloud. Early morning the visibility could have been down to about 7 km because of haze but this would have improved from 0700Z onward. Temperature would have been in the region of 25℃ t o 29℃.

1.8 Aids to navigation

1.8.1 The aircraft was fitted with a KX 155 TSO communication/navigation receiver, and there were no reported defects to the system before the flight.

1.8.2. The aircraft was also fitted with a GPS unit which was switched off and sealed as it was prohibited for the race.

1.9 Communications

1.9.1 The aircraft was fitted with a KX 155 TSO communication/navigation receiver, and no anomalies were reported prior to the accident, and there were no reported defects to the system before the flight. The pilot never made a distress call before attempting the forced landing.

1.9.2 The pilot reported the accident to the organisers of the race using his cellular phone, after they had safely disembarked the aircraft.

1.10 Aerodrome information

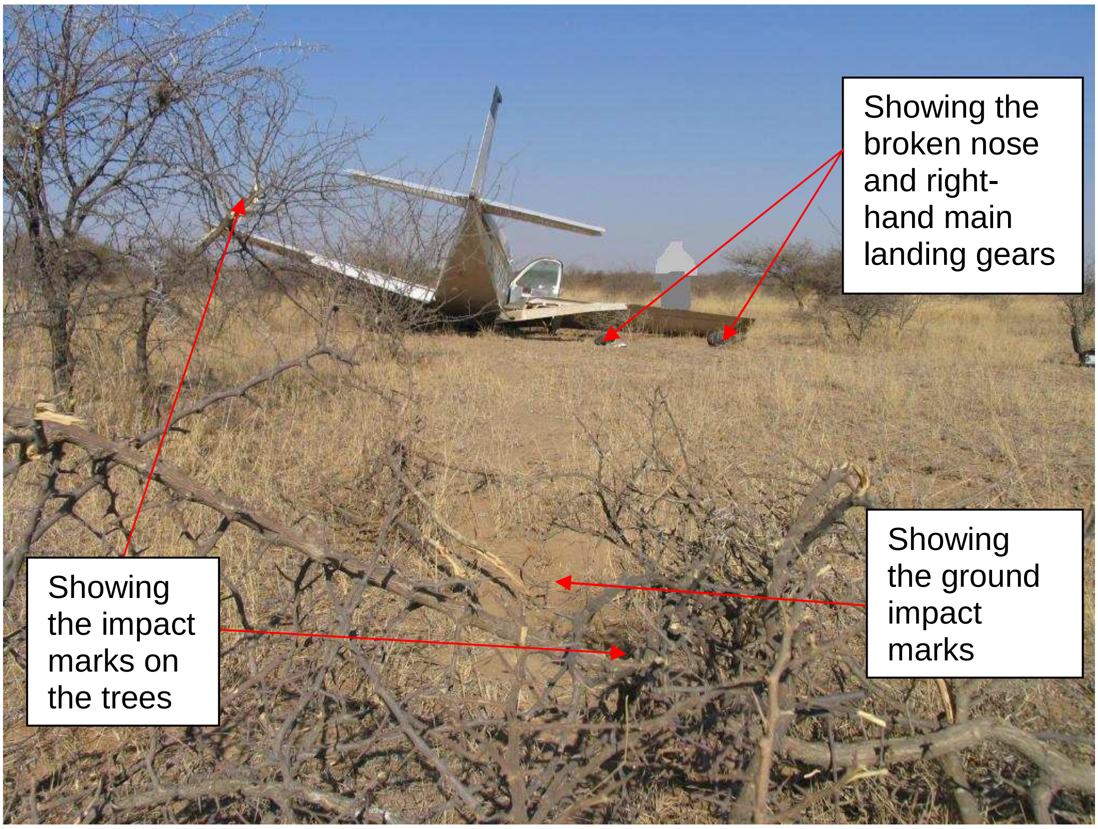
1.10.1. The accident did not occur on an aerodrome. It occurred on a private farm (Appelfontein) on a bushy terrain, at a geographical GPS position determined to be S23°23.296′; E029°11.743′, at an elevation of 3397 feet.

1.11 Flight recorders

1.11.1 The aircraft was not fitted with either a cockpit voice recorder (CVR) or a flight data recorder (FDR), nor was it required by regulation.

1.12 Wreckage and impact information

1.12.1 The aircraft impacted the terrain at a high speed on a heading of 150°M (Magnetic). The aircraft was in a wings level attitude when it first impacted a 1 metre high ridge which broke off the nose landing gear and caused the aircraft to bounce. The aircraft then impacted three thorn trees approximately 10 meters further on. The nose and the right main landing gears broke off on impact with the ground. The aircraft came to rest in a right wing low attitude, approximately 55 metres from the initial point of impact.The right wing and flaps sustained substantial damages.



Picture 2: Showing impact and skid marks.

1.12.2.All debris and broken parts, including the nose and right main landing gear, were found within a radius of 50 metres from the main wreckage.

1.13 Medical and pathological information

1.13.1 None of the occupants of the aircraft sustained any injuries in the accident.

1.14 Fire

1.14.1 There was no evidence of pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The accident was considered survivable as the pilot and passenger were properly restrained and the cabin remained intact.

1.15.2 The occupants of the aircraft disembarked the aircraft unassisted.

1.16 Tests and Research

1.16.1 Engine examination

(i) After the aircraft was recovered to an approved aircraft maintenance organisation (AMO), the engine was examined and a decision to conduct an engine run on the aircraft was taken. On the first engine start attempt, a spluttering noise was heard coming from the engine and the engine run was discontinued.

(ii) The engine (Continental IO-520, serial number 822795-R) was then removed from the aircraft and transported to an approved AMO for a teardown inspection under the supervision of the Investigator-in-charge. During the teardown inspection it was discovered that several teeth on the cam drive gear and its mating idler gear had failed (see picture 3). The engine teardown was nonetheless completed, and no other anomalies were observed. Both gears were removed and taken to a laboratory for metallurgical examination.

1.16.2. Metallurgical examination

(i) The cam drive gear and its mating idler gear were submitted to a metallurgical engineer for examination following failure in service and a subsequent teardown inspection.

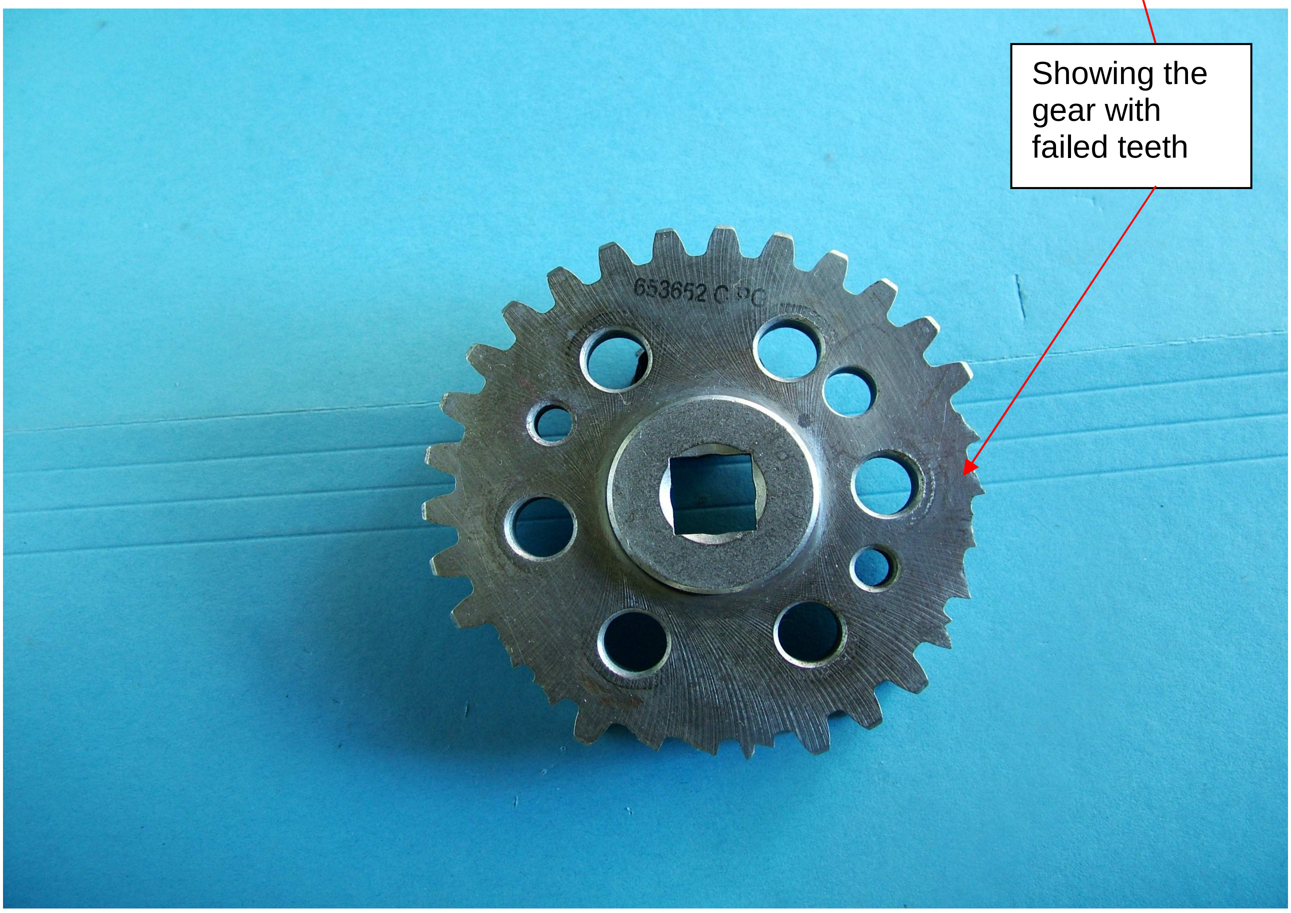
(ii) Conclusions based on that examination are as follows:

- The cam drive gear failed in fatigue, causing four adjacent teeth to become detached. These detached teeth then caused further consequential damage to both the cam drive and idler gears.

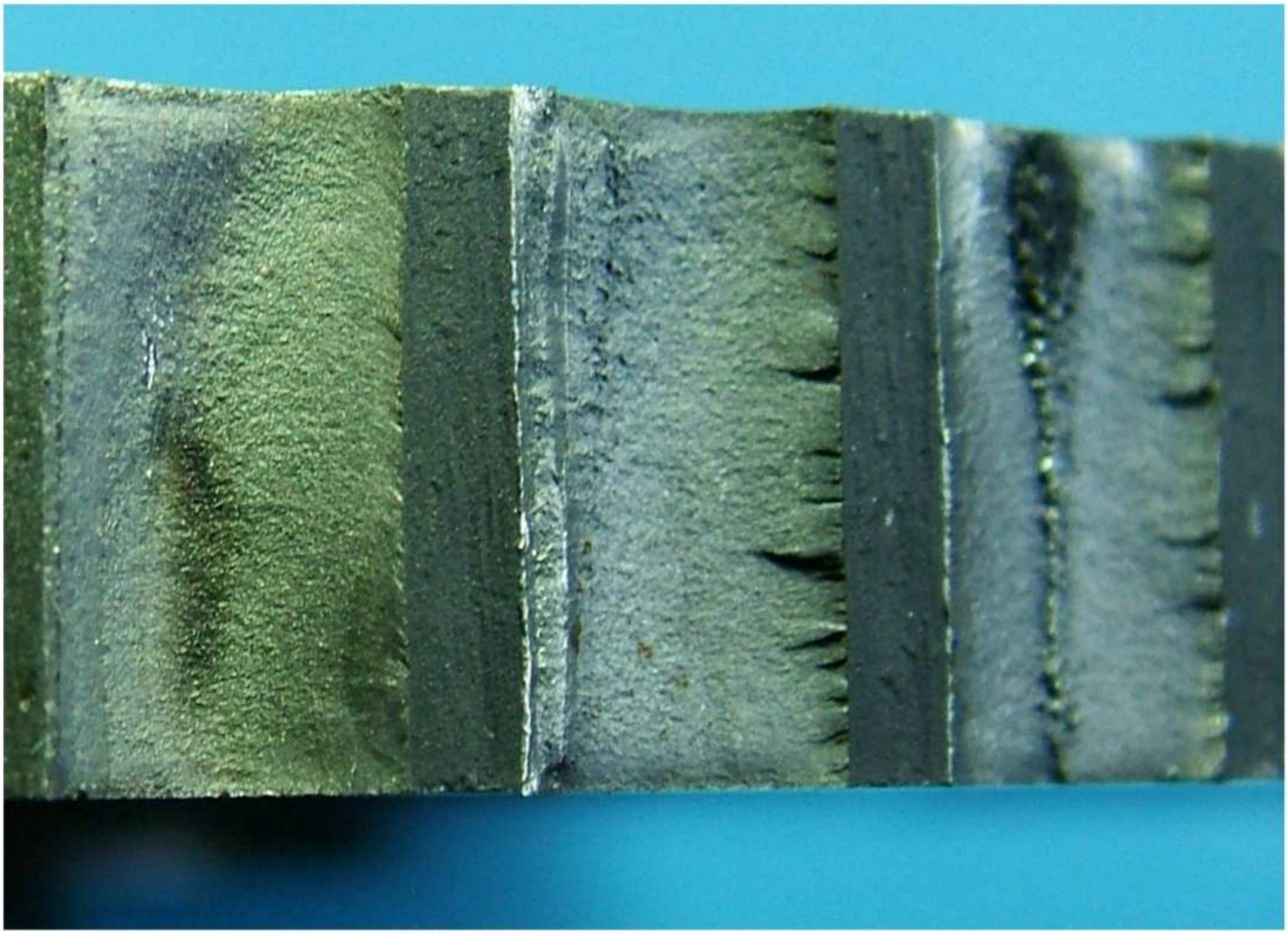
- The cam drive gear was of a suitable material for the application, but the nitriding treatment (a heat treatment process to increase the endurance limit in fatigue) had failed to give the surface hardness expected. This would result in a low tensile strength on the surface, and thus a reduced resistance to fatigue.

- The root radii on the cam drive gear were smaller than those on the idler gear. This would have given a stress-concentrating effect in this area in service, further adding to the likelihood of fatigue initiation. The full metallurgical report is attached to this report as Appendix A.

Picture 3: showing cam drive gear with failed teeth



Picture 3: Showing the idler gear with failed teeth.



Picture 4: showing fatigue progression on the damaged teeth of the cam drive gear

1.17 Organizational and Management Information

1.17.1 This was a private recreational flight. The aircraft was participating in an air race (Race of Champions) conducted from Tzaneen Aerodrome.

1.17.2 The Aircraft Maintenance Organisation responsible for the maintenance of the aircraft had a valid AMO approval certificate which was issued on 01 May 2009 and had an expiry date of 30 April 2009.

1.18 Additional Information

1.18.1 **How cams work** (abstract from the internet by Karim Nice) www.howstuffworks.com

- The camshaft uses lobes (called cams) that push against the valves to open them as the camshaft rotates, and springs on the engine valves return them to their closed position.

- The motion of the crankshaft controls the action of the engine valves, which then regulates the amount of fuel/air mixture that powers the engine. This is a critical job, and can have a great impact on an engine's performance at different speeds

1.19 Useful or effective investigation techniques

1.19.1 None.

2. ANALYSIS

2.1.1 The aircraft was participating in an air race (Race of Champions) taking place from Tzaneen Aerodrome (FATZ).Approximately an hour and ten minutes into the race, flying between Marble Hall and Vivo, the pilot experienced a sudden loss of engine power and a subsequent engine failure. The pilot spotted an open field on a farm (Appelfontein) and decided to execute a forced landing, during which the aircraft sustained substantial damages.

2.1.2 During the engine examination it was established that the engine had lost power and failed due to failure of the camshaft drive and idler gears. The gears failed as a result of metal fatigue and because the root radii on the cam drive gear teeth were smaller than those on the idler gear.

2.1.3 Given the extent of the internal damages to the engine, the pilot would have been unable to restart the engine. This left the pilot with only one option, to attempt an emergency landing without engine power, which resulted in substantial damage to the aircraft.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was the holder of a valid private pilot licence and had the aircraft type endorsed in his logbook.

3.1.2 The maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures.

3.1.3 The last MPI was certified on 15 May 2008 by AMO no.1029 at 4113.95 airframe hours and the aircraft had flown a further 15.2 hours since the last MPI was carried out.

3.1.4 The AMO that carried out the MPI on the aircraft had a valid AMO approval certificate which was issued on 01 May 2009 and had an expiry date of 30 April 2009.

3.1.5 Weather conditions were reported to be fine in the Dendron area with a light north-easterly wind and a temperature in the region of 25℃ to 29℃.

3.1.6 The engine was rebuilt and zero-timed on 24 August 2001 by Teledyne Continental Motors in accordance with an FAA-approved Quality Approved System.

3.1.7 The engine failure was attributed to the failure of the cam drive gear and its meshing idler gear.

3.1.8 The cam drive gear failed through fatigue, causing four adjacent teeth to become detached. The nitriding treatment on the cam drive gear failed to give the surface hardness expected. This resulted in a low tensile strength on the surface and thus a reduced resistance to fatigue.

3.1.9. The manufacturer stated that there were no batch records available on these gears.

3.2 Probable Cause(s)

3.2.1 Unsuccessful forced landing as a result of loss of engine power followed by an engine failure.

3.3. Contributory factor/s

3.3.1. Failure of the camshaft drive and idler gears.

3.3.2. Metal fatigue.

4. SAFETY RECOMMENDATIONS

4.1 It is recommended that the SACAA airworthiness department notify the airworthiness authority of the engine manufacturer of the defective manufactured camshaft and idler gear items, and the lack of traceability thereof, to enable introduction of improved quality control during the manufacturing process.

CAA needs to assess the implications of defect on the safe operation and continued airworthiness of aircraft fitted with relevant Teledine Continental engines (type) fitted with camshaft drive and idle gears and take the necessary steps to ensure continued safe operation

5. APPENDICES

5.1 Appendix 1. Metallurgical Report.

Submitted through the office of the SM for ASP 16 March 2010.

-END-

APPENDIX A
METALLURGICAL REPORT

Error! Objects cannot be created from editing field codes.

Abstract

A cam drive gear and its associated idler gear from an aircraft engine were submitted for examination after failing in service. The cam drive gear was found to have had four adjacent teeth fail by fatigue initiating in the drive side root. The hardness of the nitrided surface was found to be well below that normally expected for such a surface, and the root radii on the same gear were considered small and were in fact smaller than those on the idler gear. Both of these are considered significant in leading to the failure.

1. Introduction.

A camshaft drive gear and it's mating idler gear were submitted to Tim J Carter Consulting for examination following failure in service.

2. Examination.

2.1 Background.

No details of the circumstances surrounding the failure were available.

2.2 Visual Examination.

The cam drive gear had lost a number of teeth, figure 1, by two distinct mechanisms. Four of the missing teeth were adjacent, and the fracture surfaces showed characteristic features indicating fatigue, figures 2 & 3. The remaining damaged teeth showed a different mechanism, typical of material being trapped in the gear bite as the gear revolved, figure 4.

The idler gear had also lost a number of teeth, figure 5. All of these appeared to have been caused by material trapped in the gear bite.

It was noted that the tooth profile on the two gears differed in the root area, with the cam drive gear having much smaller root radii than the idler gear, figures 6 & 7.

The intact teeth showed a good contact area and enabled the drive side of the cam drive gear to be identified. The level of wear, however, was minimal.

2.3 Metallurgical Examination.

2.3.1 Metallographic.

A section cut through the teeth of the cam drive gear was embedded in thermosetting resin before being polished to a 1 μm finish with diamond abrasive. After etching in Nital-2 (2%

nitric acid in ethanol) a microstructure of quenched and tempered martensite was observed in the core of the gear, figure 8. At the surface of the gear teeth, a distinct white layer was observed, figure 9, together with grain boundary networks, figure 10.

2.3.2 Chemical Analysis.

A sample of the gear material was submitted for chemical analysis to determine the material of construction, and the composition reported is given in appendix 1. As can be seen, the material is a high carbon alloy steel with chromium and molybdenum as the principal alloying elements, similar to AISI 4150.

2.3.3 Hardness Testing.

Using the specimen previously prepared for metallographic examination, hardness tests were carried out in the core and at the surface using a vickers-type diamond pyramid tester with a 1kg load. The results obtained are as follows:

	HV 1	Avg.
Core	313, 313, 314	313
Case	585, 591, 551	576

3. Discussion.

The cam drive gear has failed in fatigue, initiating in the drive-side root radius, which has resulted in four adjacent teeth breaking away. The resulting debris has caused further, consequential damage to both the cam drive gear and the idler gear with which it meshes.

The cam drive gear has been manufactured from a chromium-molybdenum alloy steel with a fairly high carbon content. As such, it is considered an appropriate material for the manufacture of a gear. It appears that an attempt has been made to surface harden the gear by nitriding, however, the hardness in the surface layer is well below the level which would be expected from such a treatment.

The principal effects of such a low surface hardness would be a reduced tensile strength, leading to a lowered fatigue strength. This will be exascerbated by the smaller root radii on the cam drive gear, resulting in an increased loading through the stress concentrating effect of the smaller radii.

4. Conclusions.

The cam drive gear has failed by fatigue, causing four adjacent teeth to become detached. These detached teeth then caused further consequential damage to both the cam drive and idler gears.

The cam drive gear was of a suitable material for the application, but the nitriding treatment had failed to give the surface hardness expected. This would result in a low tensile strength in the surface, and thus a reduced resistance to fatigue.

The root radii on the cam drive gear were smaller than those on the idler gear. This would have given a stress concentrating effect in this area in service, further adding to the likelihood of fatigue initiation.

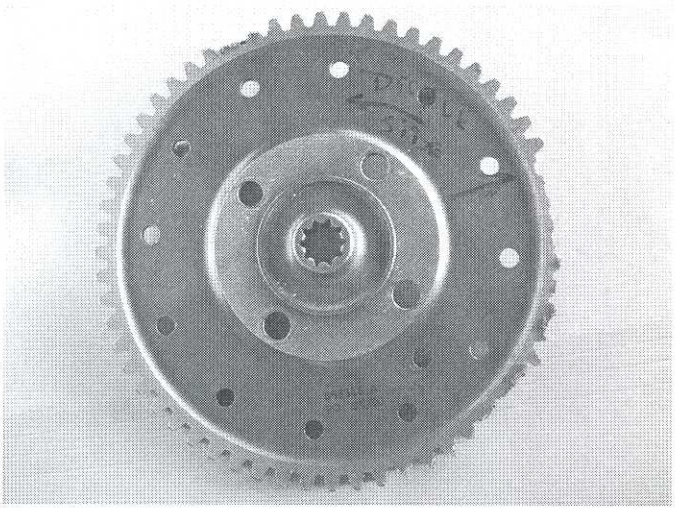


Figure 1. The cam drive gear as received, showing missing teeth.

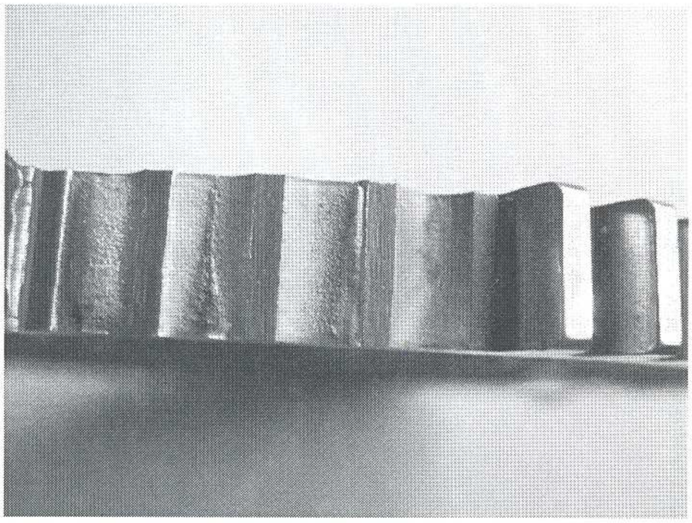


Figure 2. Characteristic fatigue features on the cam drive gear.

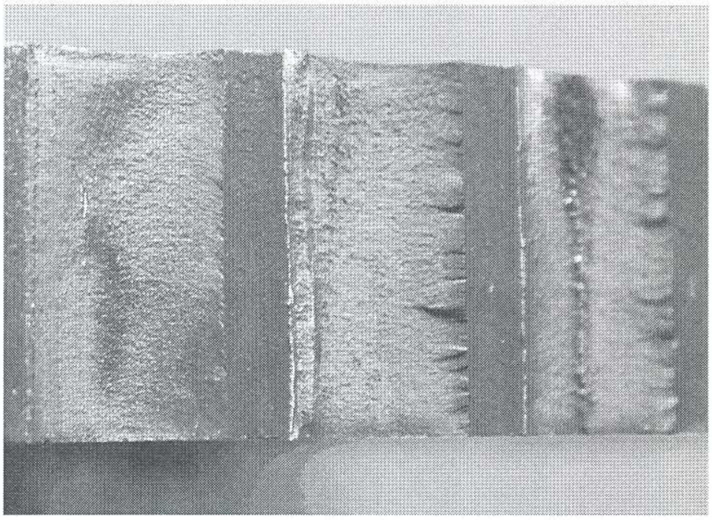


Figure 3. Ratchet marks and beach marks on the cam gear fractures, indicating origin of fracture in tooth drive side root radius.

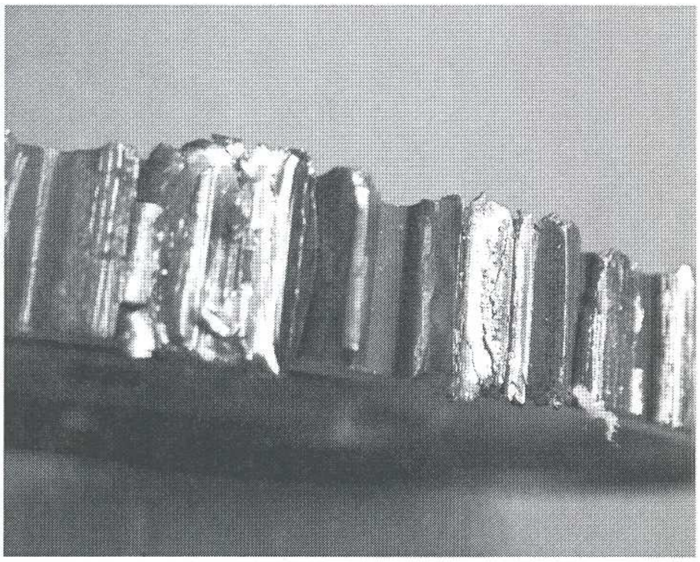


Figure 4. Consequential damage to the cam drive gear caused by debris.

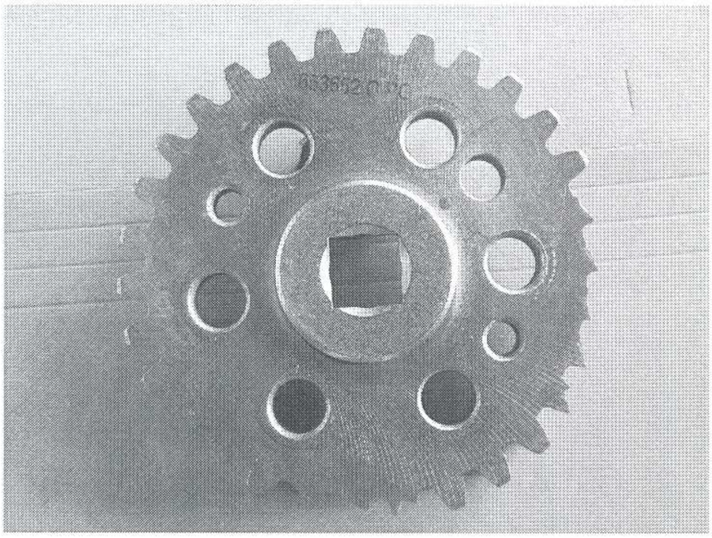


Figure 5. The idler gear showing missing teeth.

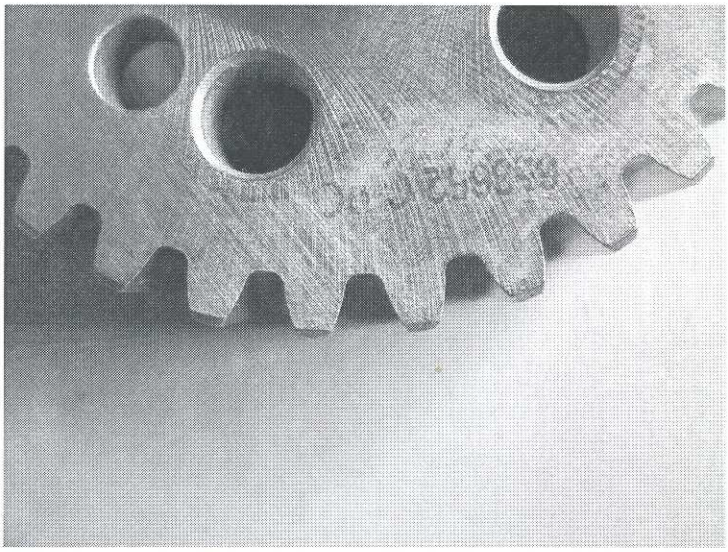


Figure 6. Tooth profile of the idler gear.

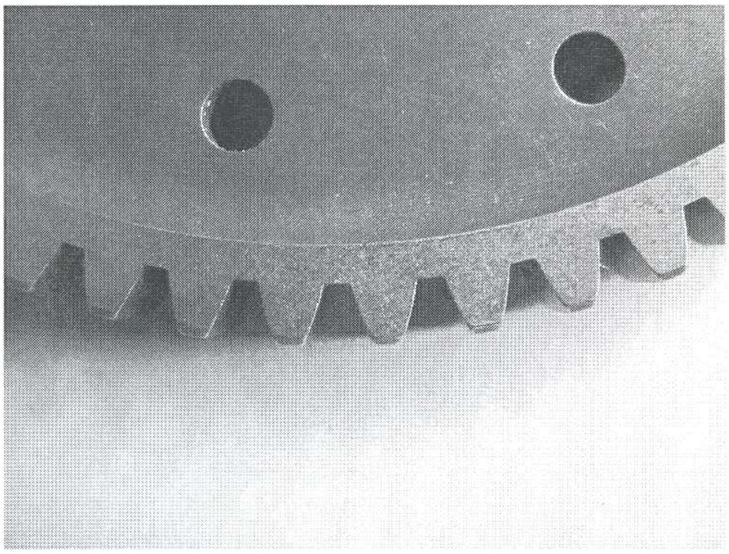


Figure 7. Tooth profile of the cam drive gear, note the smaller root radii.

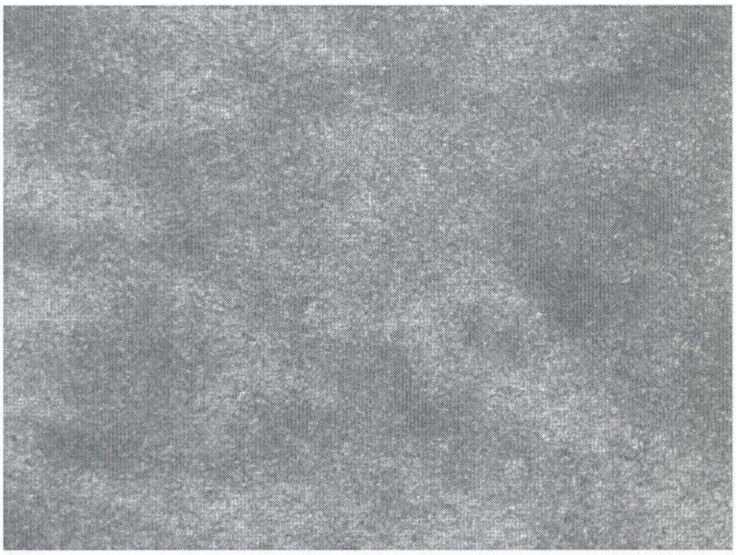


Figure 8. Microstructure of the cam drive gear core showing tempered martensite. Etched Nital-2, approx x 400.

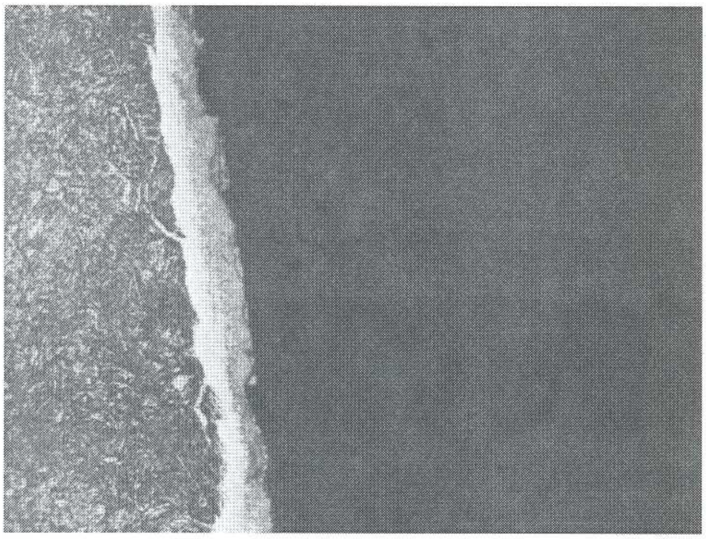


Figure 9. White layer on surface of tooth indicating nitriding process. Etched Nital-2, approx x 400.

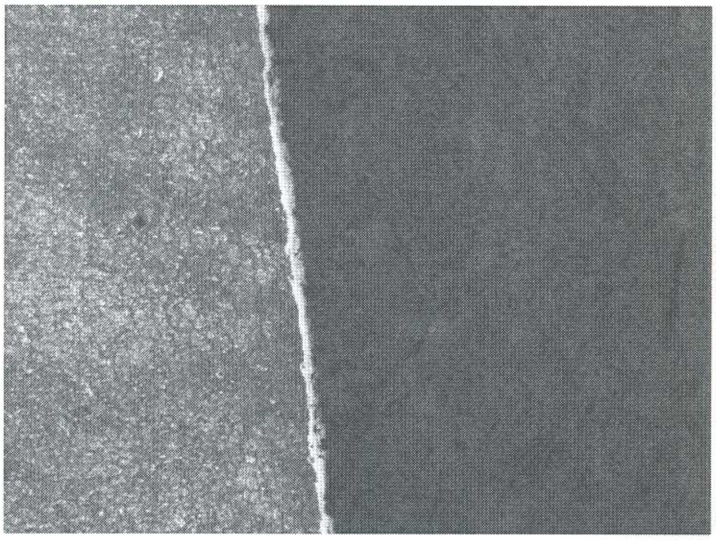


Figure 10. Grain boundary networks in area adjacent to surface. Etched Nital-2, approx x 100.

Appendix 1.

Chemical Analysis Results.

		Gear	AISI 4150
Carbon	%	0.52	0.48 - 0.53
Manganese	%	0.85	0.75 - 1.00
Silicon	%	0.27	0.15 - 0.35
Sulphur	%	0.021	0.040
Phosphorus	%	0.028	0.035
Nickel	%	0.06	-
Chromium	%	0.99	0.80 - 1.10
Molybdenum	%	0.16	0.15 - 0.25
Copper	%	0.11	-
Aluminium	%	0.026	-
Niobium	%	0.010	-
Vanadium	%	0.010	-
Titanium	%	$0.005	-
Boron	%	$0.0005	-
Iron		Balance	Balance