

\*\* EMAIL \*\*

29<sup>th</sup> June, 2022

**Travel Motors Direct Ltd**

19 Atuaroa Avenue  
Te Puke, 3119

**ATTENTION:** Mr Jeremy Rowland

PO No.

MetalTest Job No. J17033

**Subject:** A gear and associated annulus from a 2 stage reduction gearbox installed in a 6 tonne digger was submitted for chemical analysis and metallurgical examination to assess their respective qualities.

**See photographs A, B and C.**

**A. Executive Summary**

**i. Gear**

- The gear has been manufactured from steel conforming to AISI 5120 grade steel or equivalent. This is a common medium duty carburizing steel.
- Effective case depth was determined to be 0.95mm at 550HV.
- Surface hardness of the gear teeth was determined to be 710HV in a tempered martensite matrix with a bainite core of hardness 430HV.
- We are advised that this is a heavy duty gearbox and hence we would have expected the gear to have been manufactured from nickel-chromium-molybdenum steel such as EN39B or E110 for improved toughness.

**ii. Annulus**

- The annulus has been manufactured from ductile (SG) cast iron.
- The annulus is in the as-cast condition and has not been annealed or normalized as evident by the presence of “bullseye” ferrite surrounding the graphite nodules
- Metallurgical examination finds graphite morphology to have 95% nodularity with a 50/50 ferrite pearlite matrix with graphite size 5.
- Hardness was determined to be 215HV.
- Hence we have a relatively soft annulus gear – 215HV - running against a gear with a surface hardness of 710HV which will likely result in premature wear of the annulus.
- However what was incredulous to find was casting shrinkage porosity at the root of the annulus gear teeth which results in little or no impact resistance for the annulus.

- Additionally the annulus is in the as-cast condition and has not been annealed or normalized. SG iron castings such as this annulus given the service conditions in which it operates should never be used in the as-cast condition.

### **Conclusions**

- The combination of an as-cast ductile iron annulus with shrinkage porosity in contact with a carburized gear is an **unbelievably** poor combination of materials for a heavy duty gearbox.

Yours faithfully

A handwritten signature in black ink, appearing to read 'Peter Wilcox', with a stylized flourish at the end.

Peter Wilcox B.Sc (Chem)  
MetalTest & Associates Ltd

## B. Testing Results

### 1. Gear

#### Chemical Analysis Result

Sample ID	C	Si	Mn	S	P	Ni	Cr	Mo	Cu	Al	V	Ti
Gear	0.23	0.24	0.86	<0.005	0.021	0.02	1.05	<0.01	0.02	0.026	0.01	0.07

**NB.** All results above expressed as %<sup>w</sup>/<sub>w</sub>.

#### Comments

- The submitted gear has been manufactured from steel conforming to the chemical specification for AISI 5120 grade steel or equivalent. This is a common grade of carburizing steel and we note the presence of titanium (Ti) which has been added to combine with any nitrogen present to retard possible age hardening.

#### Metallurgical Examination

See **Appendix A** for determination of effective case depth which was measured to be 0.95mm to 550HV.

See **microphotograph A**.

### 2. Annulus

Sample ID	C	Si	Mn	S	P	Ni	Cr	Mo	Cu	Mg	Ti
Annulus	3.3	2.3	0.39	<0.01	0.02	0.01	0.02	<0.01	0.01	0.038	0.02

**NB.** All results above expressed as %<sup>w</sup>/<sub>w</sub>.

#### Comments

- The submitted annulus has been cast from ductile (SG) iron.

#### Metallurgical Examination

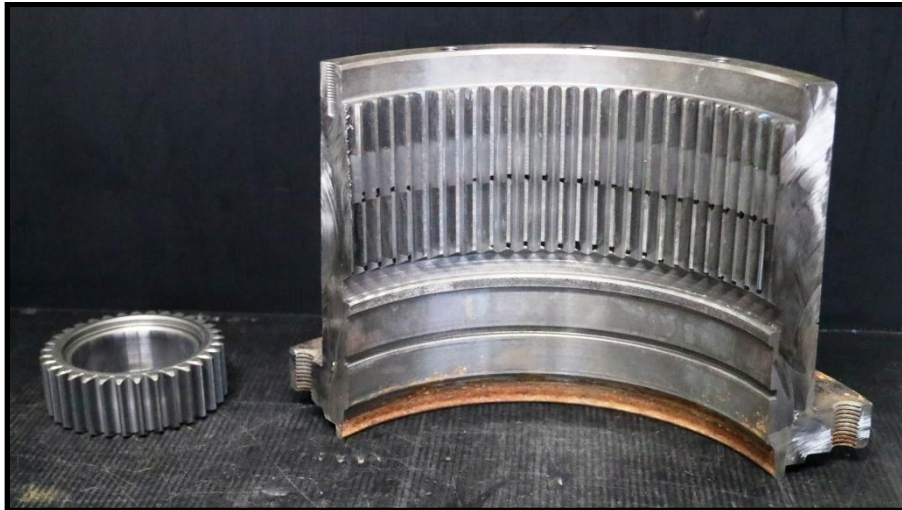
Metallurgical examination finds the annulus is in the as-cast condition where we observe shrinkage porosity at the root of the gear teeth. Hardness was determined to be 215HV.

Graphite morphology was rated to be :-

Sample ID	% Nodularity	Graphite Size	%Ferrite	%Pearlite	% Carbides
Annulus	95	5	50	50	0

See **microphotographs B, C and D**.

**Photograph A**



Sample of gear and annulus as received

**Photograph B**



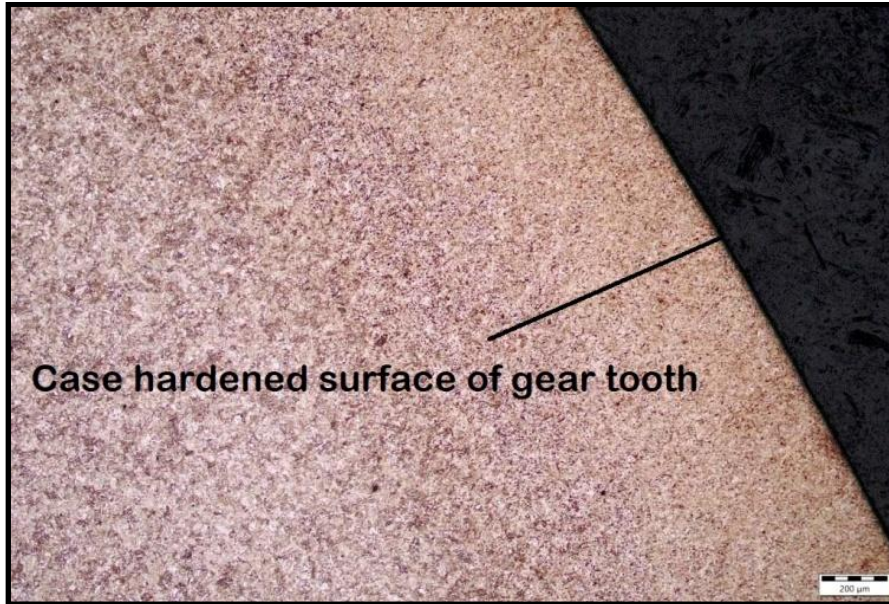
Gear identification

**Photograph C**



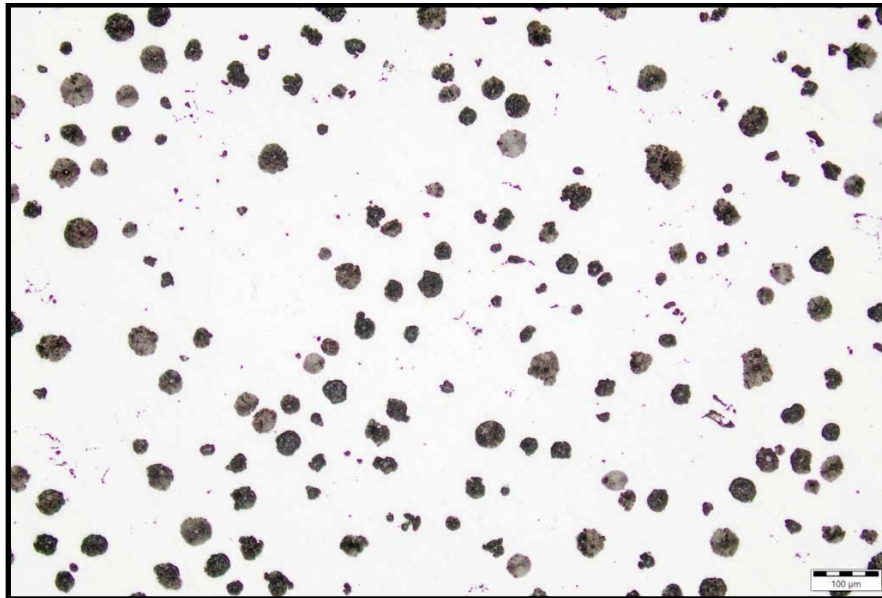
Gear in contact position within the annulus

### Microphotograph A



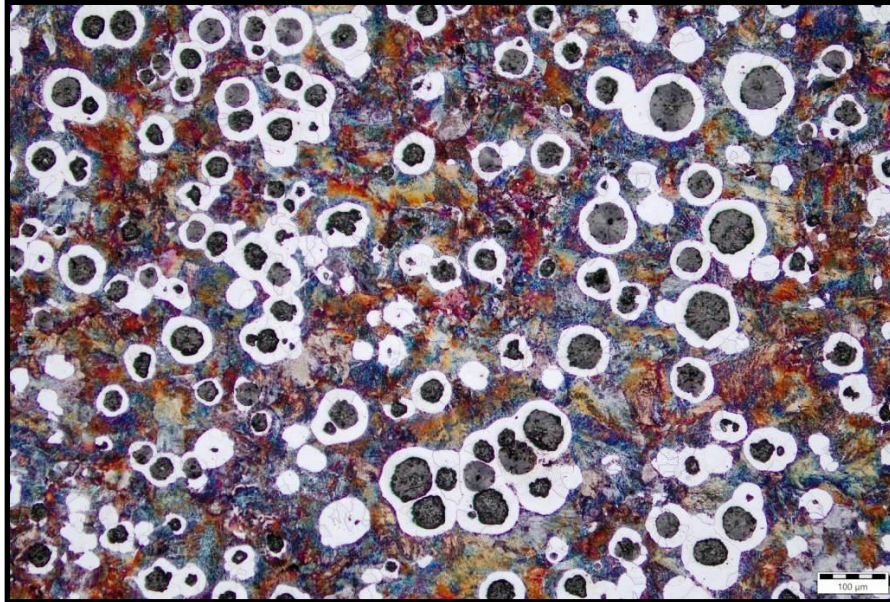
Case hardened surface of gear teeth @50x magnification - etched

### Microphotograph B



Graphite morphology of annulus @100x magnification – as polished

### Microphotograph C



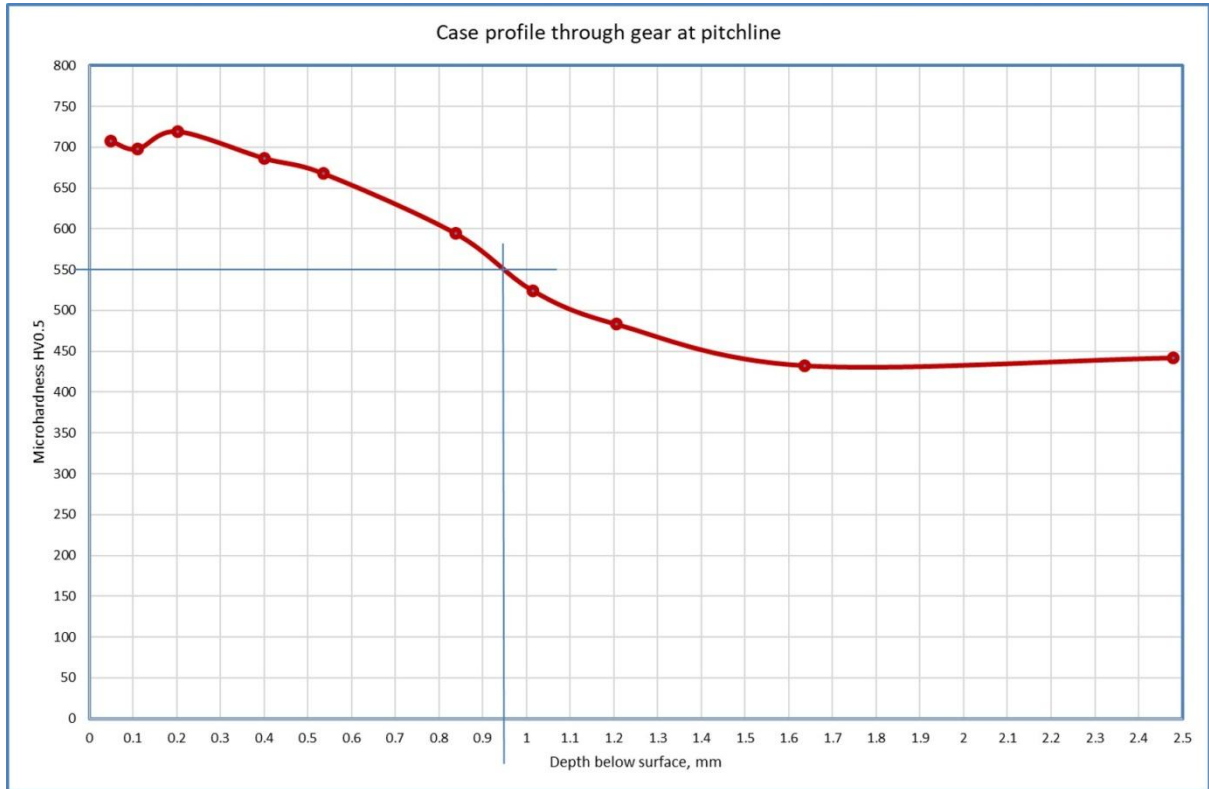
Graphite morphology of annulus @100x magnification – etched – revealing the presence of “bullseye” ferrite indicating the annulus is in the as-cast condition

### Microphotograph D



Shrinkage porosity in root of annulus gear teeth

## Appendix A



Effective Gear Case Depth