The effect of alloying elements on cast iron wind turbine components

Obey Suleyman, Tiziana Marrocco, Fiona Sillars, Maider Olasolo

UNIVERSITY of STRATHCLYDE
ADVANCED MATERIALS RESEARCH LABORATORY

**Advanced Materials Research Laboratory,
University of Strathclyde, Glasgow
obey.suleyman.2017@uni.strath.ac.uk**

Renewable Parts Ltd

NMIS National Manufacturing Institute Scotland

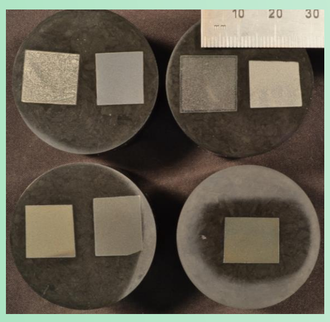
What components?

Wind turbine

Planetary gearbox

Planetary gears within the gearbox

Sectioned planetary gears



Samples of gears, pre and post heat treatment

LinkedIn

Background

The concept of circular economy is at the forefront of current global discussions due to the alarming rate at which natural resources are being used. Remanufacturing is a topic which has been firmly embedded in several sectors, but it is still at its relative infancy with respect to the renewables sector.

The problem…

Up to 50,000 wind turbines will be decommissioned nationwide by 2050, resulting in around 70 million tonnes of waste [1]. There is a lack of end-of-life solutions for wind turbines, with many components being disposed in landfill. Solutions such as component remanufacturing and life extension must be advanced to achieve a circular economy.

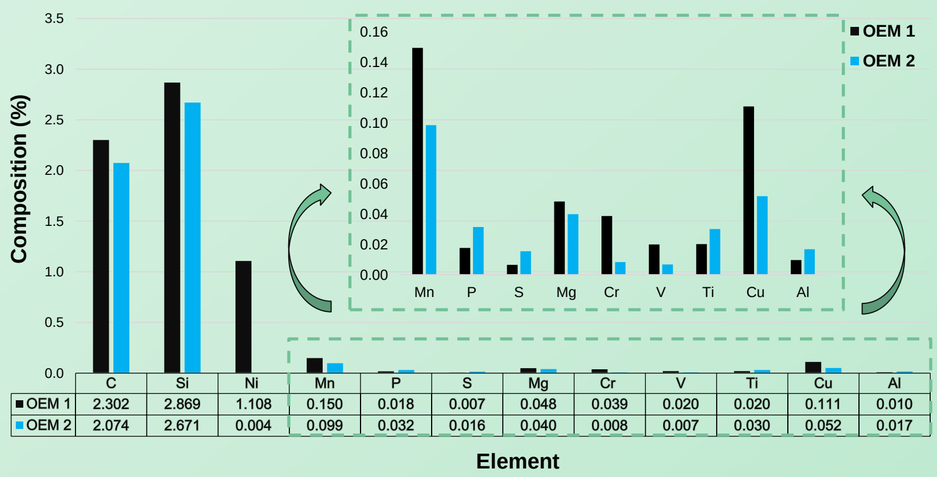
In this project, particular focus will be on two cast iron planetary gears, from differing Original Equipment Manufacturers (OEM's). Samples from both gears will be prepared in its original state (as-cast), in addition to two heat treated states (annealed and quenched and tempered). The aim is to understand the effect of the alloying elements within these components, through achieving the project objectives below.

Project objectives

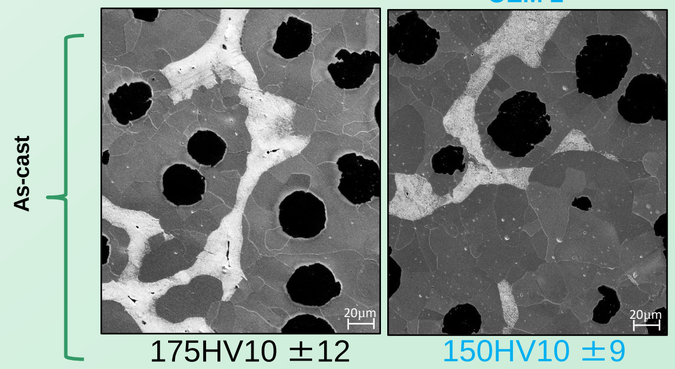
Complete elemental analysis of planetary carriers to establish similarities and differences between the two OEM's → Investigate the effects of the elemental differences within the two carriers by analysing their microstructures → Compare macro-hardness values between carriers to understand element effects on mechanical properties → Propose solutions to improve the material properties and extend the lifetime of these carriers

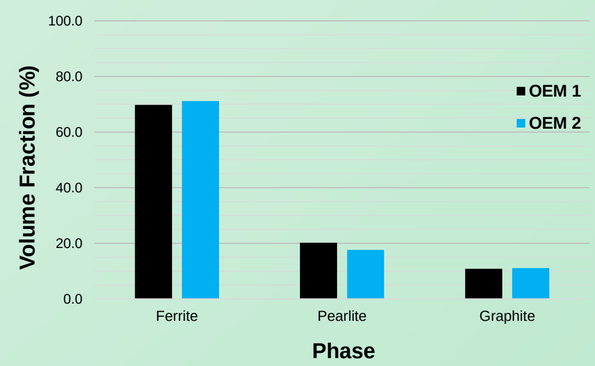
Current findings

- Using GD-OES, the composition of these carriers were accurately determined.
- Significant contrasts in various elements such as Ni, Mn, Cr, Cu.
- These elements are seen as 'strengtheners' [2] and are all higher in the OEM 1 results.
- Microscopy, hardness and volume fractions were analysed in all three states for both gears.

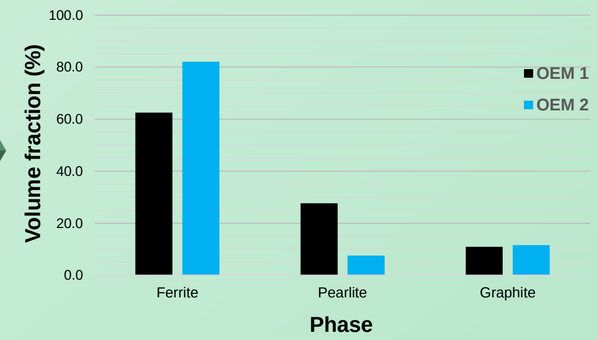


	C	Si	Ni	Mn	P	S	Mg	Cr	V	Ti	Cu	Al
OEM 1	2.302	2.869	1.108	0.150	0.018	0.007	0.048	0.039	0.020	0.020	0.111	0.010
OEM 2	2.074	2.671	0.004	0.099	0.032	0.016	0.040	0.008	0.007	0.030	0.052	0.017

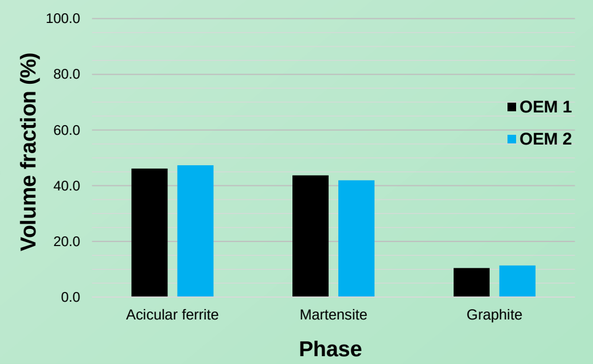




- Sample from OEM 1 has a slightly higher hardness.
- From microscopy/volume fraction, OEM 1 has a higher pearlite fraction, which is a harder phase than ferrite.



- Sample from OEM 1 has a significantly higher hardness.
- 20% difference in pearlite fraction provides this increase in hardness.



- Both hardness values relatively similar.
- Similar volume fractions and so hardness values are alike.

Conclusions

- Alloying elements have a significant effect on the cast iron, as evident through the variation in results due to the 'strengtheners' found in the planetary carriers from OEM 1.
- These strengthening elements also had an effect on the microstructural phases both in the original and as-cast condition, typically preferring to form pearlite over ferrite, hence the hardness differences.

Future work

- Mechanical testing to study the effect alloying elements have on performance properties such as yield strength and ductility.
- Link all results together to make a proposal for an optimal planetary carrier with regards to elemental composition and heat treatment.

References

[1] .P. D. Modica, "Embarking on Sustainable Decommissioning," 11 07 2022. [Online]. Available: https://www.renewable-parts.com/Portals/0/MC04%20KTP%20A5%20Leaflet%20V02.pdf.
[2] Lian, X. T., Zhu, J. N., Dong, H., Wang, Y. M., & Liu, J. D. (2020). Effects of Micro-Alloying Elements on Microstructure, Element Distribution and Mechanical Properties in Gray Irons. *International Journal of Metalcasting*, *14*(4), 1025–1032. https://doi.org/10.1007/s40962-019-00402-4

Acknowledgements

Thanks to my project funders; SEA-SRSS, Advanced Materials Research Laboratory (AMRL), National Manufacturing Institute Scotland (NMIS), Renewable Parts Limited (RPL)