

Assessment of Retained Austenitic Phase in Indefinite Chill Cast Iron Microstructure Towards Various Techniques

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Abstract

Indefinite Chill Cast Irons are high alloyed cast iron alloys belonging to the Fe-Cr-C-X system, with Ni, Cr, Si, Mn and Mo as major alloying elements. The casting process of such an alloy when it is performed in a classic way (air cooling) leads to a mixture of free graphite, Cementite, martensite, and a certain amount of retained austenite (RA) that is unavoidable in applications involving high stresses and heating-cooling sequences such as Hot Strip Mill. RA yields martensite in ICDP alloys while performing multiple tempering heat treatments in order to complete this phase transformation.

The present study is intended to compare various complex techniques such as XRD, CEMS and VSM used for RA assessment issues, the final goal being the calibration of a classic and rougher method such as Dilatometry to allow a fast and reliable technique for RA measurements.

INTRODUCTION

Indefinite Chill Cast Irons also called ICDP when used as rolling mill rolls are high alloyed cast iron belonging to the Fe-Cr-C system. Precipitation at the same time of free graphite and carbides during the casting process leads to "IC" specific designation. ICDP exhibit improved properties regarding hot oxidation and wear resistances as their microstructure is a mixture of a martensite with bulky Cementite (M₃C) and lamellar graphite fully dispersed into the matrix. Mechanical properties involved depend either on the chemical composition of the alloy or the crystallisation behaviour and the heat treatments performed subsequently in order to lead to the desired microstructure.

Retained Austenite always present in ICDP microstructure at the end of casting process is of concern regarding applications such as hot rolling mill as this austenitic phase is well-known to be unstable during possible rolling incidents on rolls. Thus subsequent tempering heat treatments are performed at the end of casting procedure in order to allow a fully transformation of RA into an expected and advisable martensite.

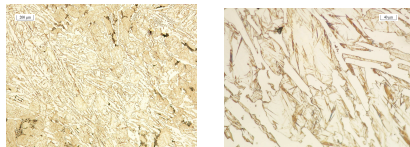
From an industrial point of view, it is important to set a fast and reliable method to assess RA presence into ICDP microstructure at the end of every single step of the thermomechanical process for cost issues.

Common techniques such as optical microscopy linked to Image Analysis seem to be unsuitable for such an estimation as austenite and martensite appeared inter mixed in the matrix. The present work is intended to compare different techniques used for RA assessment in ICDP alloys starting from complex, refined and accurate methods such as X-Ray Diffraction (XRD) and even more exotic Conversion Electron Mössbauer Spectroscopy (CEMS) to yield the calibration of a rougher one such as Dilatometry.

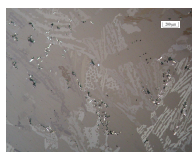
MATERIALS

C	Si	Mn	Ni	Cr	Mo	Fe
3.2/3.5	0.9/1.1	0.9/1.0	4.2/4.5	1.3/1.9	0.3/0.4	Bal.

Average chemical composition of ICDP (-%weight)



ICDP microstructure (as-cast conditions) with free graphite (dark) and martensite-austenite mixture (Nital etching - Bright Field)

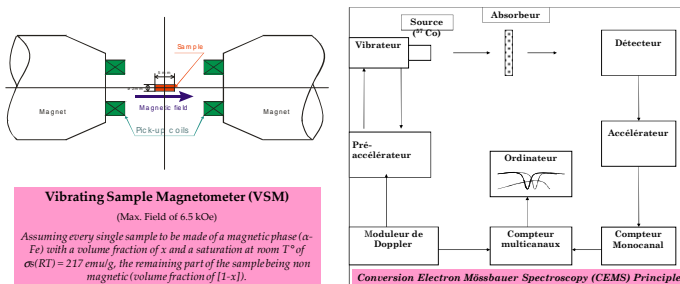


ICDP microstructure (as-cast conditions) with free graphite (dark), Cementite and Matrix (As-polished; Crossed Nichols)

After 3 times tempering, microstructure is fully martensitic with around 35 to 45% of Cementite, and 1 to 3% of free graphite.

Average Hardness is around 600 HV, with a more or less wide scattering depending on the material itself or the heat treatments performed.

TECHNIQUES USED FOR R.A. ASSESSMENT



REFERENCES

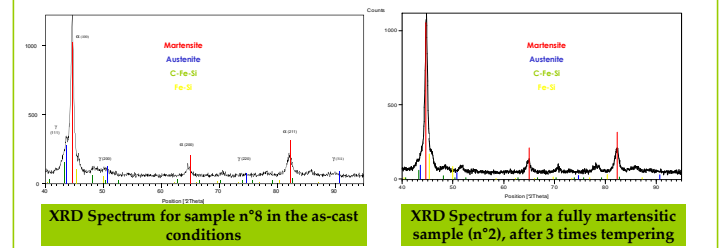
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Acknowledgements

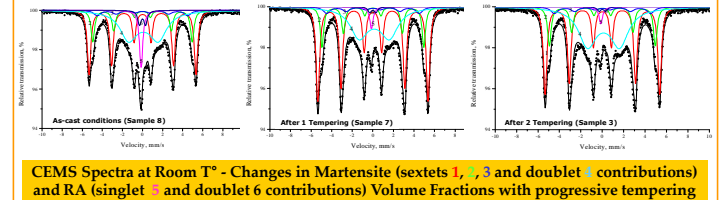
The authors would like to thank Marichal Ketin Belgium for providing materials and both the "Communauté Française de Belgique" and the "Région Wallonne" for their support.

RESULTS

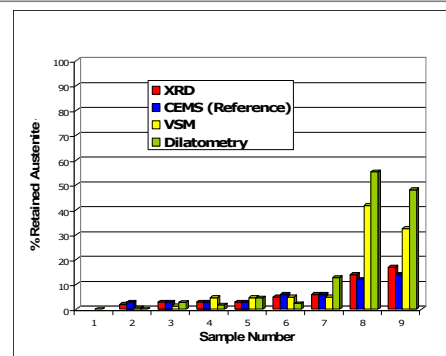
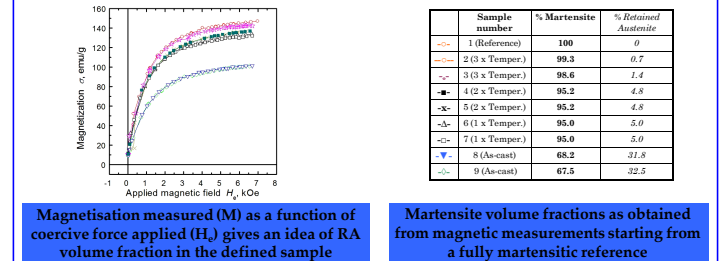
From XRD Analysis...



From CEMS Technique...



From VSM Measurements...



CONCLUSIONS

Dilatometry seems to overrate retained austenite volume fraction in the as-cast conditions while good agreements are made on the overall batch of techniques when considering heat treated material where retained austenite transformation occurred. CEMS seems to be the more accurate technique for RA assessment.