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Effect of degeneracy in graphite particle aspect ratio (AR) on some mechanical properties of as-cast spheroidal graphite iron (SGI)-compacted graphite iron (CGI) cast iron series

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Statement of the Problem: Spheroidal Graphite Iron (SGI) and Compacted Graphite Iron (CGI) castings and their derivatives have proven to be the cost-effective materials of choice and/or potential alternatives to other conventional/competing materials (e.g. malleable iron, steel, aluminum, etc., castings) and manufacturing processes (forging, machining, fabrication, etc.) in many automotive and industrial applications, with either an outright improvement in service performance or lower production cost or both. The general properties of this set of engineering purpose cast irons (often used as-cast) depend largely on the relative amount, distribution, structure and morphology of the characteristic graphite component, thus impacting significant measure of ductility in the system. Chemistry and processing of the melt dictate both the desirable graphite structure/morphology and the matrix structure during solidification. However, occasionally, consistent and uniquely spheroidal or compacted form-types of graphite required, are not readily obtained in regular production of these irons. This may result from insufficient or excessive melt treatment, choice and mode of addition of the graphite nodularising treatment agent, non-uniform treatment or the presence of inhibiting elements.

Methodology & Theoretical Orientation: A range of un-alloyed SGI-CGI iron grades were produced in a series of systematic iron-melt treatments with a special Ca-CaC2-Mg master alloy. Data sets are presented and analyzed to gauge the effect of variation in graphite particle Aspect Ratio (AR) range in an as-cast SGI-CGI iron series ranging from ASTM type I (fully spheroidal) to ASTM types II-III-IV (mixture of spheroidal and compacted/vermicular graphite forms) on some of their selected mechanical properties.

Findings: It was observed that generally, properties relating to strength and ductility progressively decrease as the proportion of non-nodular graphite (AR≤0.65) increases. In particular, properties relating to failure (tensile and fatigue strengths) are more affected by small amounts of such irregular graphite forms than properties (proof strength, etc.) not involving failure.

Conclusion & Significance: This research has established that in general, the level of graphite spheroidization or nodularization (as measured by the graphite particle AR), plays a significant role in determining the resulting mechanical properties in the SGI-CGI family spectrum. Conversely, increasing amounts of non-spheroidal graphite particles, either in the compacted or degenerate form (vermicular) caused progressive reductions in tensile and yield strengths, ductility (% elongation), notch impact values, fatigue limit and modulus of elasticity. Thus, the level of graphite spheroidization in either the optimum SGI or CGI is critical to its consideration for applications in functional components in automobile, heavy machinery, etc. and in applications where some degree of toughness is required.

Biography

Benjamin I Imasogie has special interest and expertise in the development and characterization of ductile iron; DI (also known as spheroidal (SGI) or nodular graphite iron (NGI), Austempered Ductile Iron (ADI) and nanostructured (LIGA-Ni-Fe MEMS) engineering materials. He has written and presented several scholarly papers on these topics in high impact materials science and engineering journals such as MST, SJM, JMEPEG-ASM, Materials Performance (MP), JMMCE, ACMM, MEJ, NJMSE, Acta Materialia, Metall. and Matls. Trans., Mater. Sci. and Engg. A, etc. With respect to the pertinent paper, he is the Author of the special resource material. He is the current Dean, Faculty of Technology, Obafemi Awolowo University, Ile-Ife, Nigeria. He is a Professor of Materials Engineering in this renowned University. He is a Fellow of the Nigerian Society of Engineers (FNSE) and the Nigerian Metallurgical Society (FNMS).

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