Uncovering the local inelastic interactions during manufacture of ductile cast iron: How the substructure of the graphite particles can induce residual stress concentrations in the matrix

Recent X-ray diffraction (XRD) measurements have revealed that plastic deformation and a residual elastic strain field can be present around the graphite particles in ductile cast iron after manufacturing, probably due to some local mismatch in thermal contraction. However, as only one component of the elastic strain tensor could be obtained from the XRD data, the shape and magnitude of the associated residual stress field have remained unknown. To compensate for this and to provide theoretical insight into this unexplored topic, a combined experimental-numerical approach is presented in this paper. First, a material equivalent to the ductile cast iron matrix is manufactured and subjected to dilatometric and high-temperature tensile tests. Subsequently, a two-scale hierarchical top-down model is devised, calibrated on the basis of the collected data and used to simulate the interaction between the graphite particles and the matrix during manufacturing of the industrial part considered in the XRD study. The model indicates that, besides the viscoplastic deformation of the matrix, the effect of the inelastic deformation of the graphite has to be considered to explain the magnitude of the XRD strain. Moreover, the model shows that the large elastic strain perturbations recorded with XRD close to the graphite–matrix interface are not artifacts due to e.g. sharp gradients in chemical composition, but correspond to residual stress concentrations induced by the conical sectors forming the internal structure of the graphite particles. In contrast to common belief, these results thus suggest that ductile cast iron parts cannot be considered, in general, as stress-free at the microstructural scale.
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.6 SJR 2.799 SNIP 2.25
Web of Science (2011): Impact factor 2.806
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.309 SNIP 2.451
Web of Science (2010): Impact factor 3.705
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.918 SNIP 2.149
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 3.557 SNIP 2.578
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.618 SNIP 2.635
Scopus rating (2006): SJR 3.797 SNIP 2.684
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.903 SNIP 2.47
Scopus rating (2004): SJR 4.274 SNIP 2.764
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 4.603 SNIP 2.999
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 4.04 SNIP 2.353
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 3.541 SNIP 2.66
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.594 SNIP 2.492
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.628 SNIP 2.25
Original language: English
Keywords: Thermomechanical processes A, Residual stress B, Inhomogeneous material B, Elastic-viscoplastic material B, Cast iron, Graphite
DOIs: 10.1016/j.jmps.2017.11.005
Source: Findit
Source-ID: 2393298890
Research output: Research - peer-review › Journal article – Annual report year: 2018