Finite element modeling investigations on a ductile cast iron
EN-GJS-600-3 yield locus under biaxial stresses

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Experimental data

The yield domain of a ductile cast iron (DCI) EN-GJS-600-3 was investigated by testing tubular specimens under several biaxial loading conditions. The morphology, distribution and dimensions of graphite nodules were characterized through light optical metallography and computed tomography. The yield locus of the material deviates from that predicted by von Mises. It is well-fitted by the three-dimensional invariant-based criterion proposed by Camanho. This work presents finite element simulations to investigate the deviation from the von Mises yield domain.

2D models

2D simulations were performed plane stress conditions. For tensile axial components, the graphite nodules were modeled as circular voids. Instead, for compressive axial components, the effect of graphite nodules is no longer negligible. Therefore, it was decided to model them as compressible fluids surrounded by the matrix and with an initial circular shape. This assumption is reasonable as graphite is a solid lubricant with very low mechanical strength and therefore able to easily deform even at low applied stresses. A Python\textsuperscript{\textregistered} script was implemented to generate 50 different 2D rectangular domains with dimensions of approximately 2 x 2 mm, where the graphite nodules are dispersed according to the experimental data. The yield strength and plastic modulus of the matrix were tuned according to the experimental curves, looking for the best fit. All the 50 domains were then simulated under several biaxial loading conditions.

3D model

Because of the very large computational power required for 3D simulations, it was decided to investigate only one 3D domain, generated by another Python\textsuperscript{\textregistered} script. The spatial arrangement and dimension of graphite nodules were set according to experimental data collected through computed tomography (CT) scans and observations on metallographic samples. The graphite nodules were modeled as spherical voids.

Results

The numerical results are in accordance with the experimental data, thus predicting the deviation from the von Mises yield domain. In all the loading conditions, the stress concentration factor \(K_t\) is lower than the axial one.