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FINITE ELEMNT MODELLING TO ASSESS THE EFFECTS OF THE MICROSTRUCTURE TOPOLOGY ON THE FRACTURE TOUGHNESS OF DUAL-PHASE AUSTEMPERED DUCTILE IRON

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Abstract. The engineering community is strongly pressed to produce lighter, stronger and stiffer metallic parts. Ductile Iron (DI) can be a material of choice to fabricate numerous parts, since it is suitable to produce high resistance cast parts of complex shape and relatively inexpensive. For this reason DI is used to successfully replace cast and forged steels parts in a large number of applications. The mechanical properties of sound DI cast parts depend mainly on the matrix microstructure (type, amount and distribution of microconstituents), the graphite phase and the cast defects present mainly in the last to freeze (LTF) regions. A wide range of microstructures, and consequently mechanical properties, can be obtained by using different heat treatments.

The effects of the microstructure topology on the fracture toughness of dual-phase austempered ductile iron are studied in this paper by means of finite element modelling and experimental testing. To this end, specimens with matrix microstructures ranging from fully ferrite to fully ausferrite were prepared and the crack propagation path studied for each microstructure by means of fractographic analyses. The preferential zones and phases for crack propagation were identified in every case. Based on the experimental observations it was proposed that the ausferrite phase plays the role of reinforcement of the ferritic matrix via the encapsulation of the brittle and weak LTF zones.

The crack behaviour was analyzed by means of finite elements via a series of two-dimensional finite element models for the material microstructure in the vicinity of the crack tip. The models were designed to mimic the different microstructures containing the graphite nodules, the LTF zones and the ausferrite encapsulations. The finite element models were discretized using 3-node linear triangular elements. The triangular elements were connected to each other using 4-node cohesive elements which account for material damage and crack propagation in every region of the model. A number of models discretized using regular and irregular meshes were solved in order to study the model convergence and to verify the independence of the results on the mesh geometry. The models were solved using Abaqus/Explicit running on a Beowulf Cluster with 8 Pentium 4 PCs.

The correlation between the crack path results computed via the finite elements models and those observed in the experimental analyses was found very good. The numerical results allow confirming the effectiveness of the ausferrite LTF zones. The toughening mechanism is consequence of the increment in the crack path longitude as it avoids the encapsulated LTF zones.