Microstructure and residual elastic strain at graphite nodules in ductile cast iron analyzed by synchrotron X-ray microdiffraction

The microstructure and residual elastic strain at graphite nodules (GNs) in ductile cast iron produced using either a fast or slow cooling rate have been characterized using synchrotron 3D X-ray Laue microdiffraction. The results show that thermal stress is introduced during cooling and that part of this stress is relaxed by plastic deformation of the polycrystalline ferrite matrix. It is found that the plastic deformation is accommodated by the formation of dislocations and dislocation boundaries, which are organized in a cell structure. The dislocation density quantified based on the microstructure is most pronounced at the GN/matrix interface around small GNs in the fast cooled sample. Residual elastic strain is also present, which is mainly compressive with a maximum of 6.0-9.9 × 10⁻⁴ near the GNs. Gradients of plastic deformation and elastic strain field around the GNs are observed. The results document for the first time that both the elastic strain field and the plastic strain field averaged over the grains around the GNs is approximately scaling with GN size and not affected by the cooling rate. The experimental data are compared with simulations by a finite element method, and agreement and disagreement are discussed in detail.