J-PARC MLF Experimental Report

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実験課題名 Title of experiment: Role of Graphite in Deformation Behavior of Ductile Cast Irons during Cyclic Tension-Compression Loading

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装置名 Name of Instrument/(BL No.)
TAKUMI (BL19)

実施日 Date of Experiment
2014/5/14 – 2014/5/17 (4 days)

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

A low carbon ferrite single phase steel and two ductile cast irons (FCD steels) with different morphologies were used in this study. The chemical compositions are shown below.

Steel	Comp.	Ferrite frac.	Pearlite frac.	Graphite frac.	Nodularity
Ferrite single phase	Ultra low carbon steel	100 %			
Ferrite matrix FCD	Fe-3.7C-2.7Si-0.3Mn	84.5 %	2.4 %	13.1 %	80.3 %
Pearlite matrix FCD	Fe-3.7C-2.7Si-0.3Mn	0.8 %	87.1 %	12.1 %	88.0 %

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

Dog-bone type specimen was prepared to have a parallel part with 6 mm diameter and 4 mm length. The specimen was mounted horizontally in a loading machine which was installed at TAKUMI, in such a way that diffraction patterns for axial (tensile) and transversal directions could be measured simultaneously by two 90° scattering detector banks. Neutron diffraction measurement was conducted with an incident slit size of 5 mm × 5 mm and radial collimators viewing 5 mm wide, i.e., the average data from the parallel part was measured. Cyclic tension-compression deformations were conducted in a continuous manner with a nominal strain rate of 5.5×10^{-6} s^{-1} in the nominal strain range of ± 1%. The nominal strain was controlled by averaging strain values measured using two strain gauges glued on the specimen parallel part. Diffraction patterns were then sliced per 300 s, and the relevant applied macroscopic strain and stress values for each slicing interval time were averaged over the slicing interval time. To observe intergranular strains, single peak fittings as well as a multi peak fitting using a Rietveld software were performed for data analyses.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

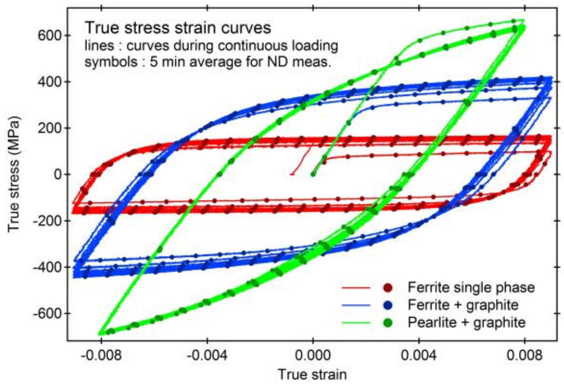

Fig. 1 Macroscopic true stress strain curves of the samples during cyclic tension-compression tests

Figure 1 shows that the tensile stresses of the ferrite single phase steel are the lowest among the three samples, while those of the FCD steel with pearlite matrix are the highest. The tensile stresses are increased in the ferrite single phase steel and in the FCD steel with ferrite matrix, showing hardening due to the cyclic loading. The ferrite phase strains in the ferrite single phase steel and in the FCD steel with ferrite matrix were increased with respect to the macroscopic strain (the results are not plotted here), being relevant to the increasing tensile stresses. However, the tensile stresses in the FCD steel with pearlite matrix are almost not changed.

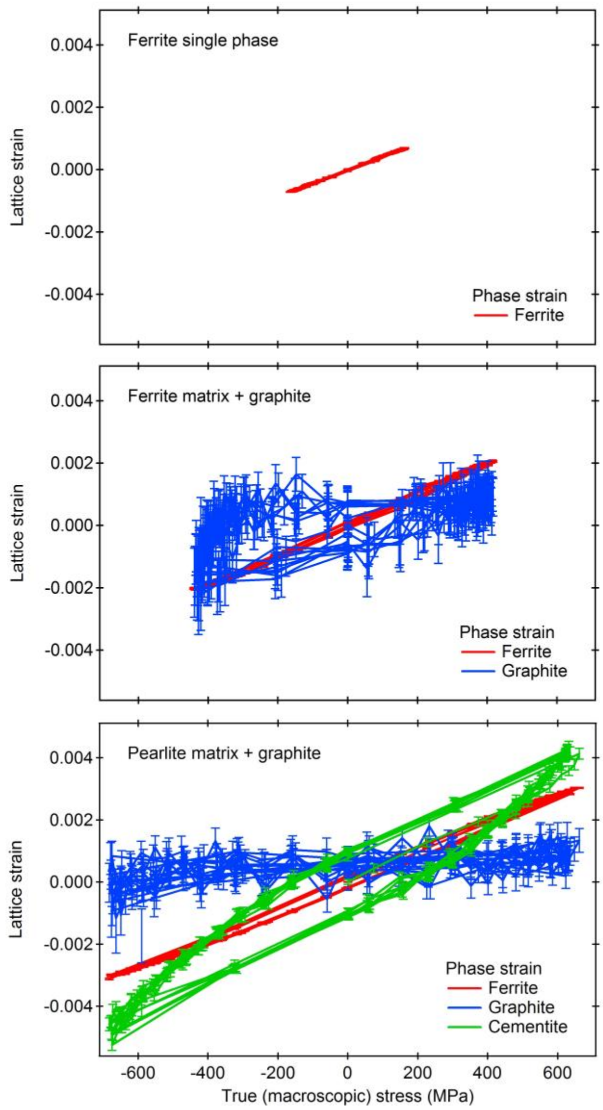

Fig. 2 Phase strain responses with respect to the macroscopic true stress in three different samples

The phase strain responses with respect to the macroscopic true stress in three samples are shown in Fig. 2. The phase strain response in the ferrite single phase steel is linear to the macroscopic true stress even the sample is deformed plastically. In FCD steels, where different phases exist, the responses deviate from the linearity at higher stress levels, i.e. elasto-plastic deformation stage, because load sharing among constituent phases due to the different deformability and elastic stiffness. From comparison of the responses in two different FCD steels, it is clear that the different matrix gives different responses in all constituent phases, and these influence to the macroscopic stress-strain.

Note: The diffraction peaks of cementite were also recognized in the FCD steel with ferrite matrix, due to the small amount of pearlite. Lattice strains for cementite, however, were difficult to be determined, because those peaks were very small.