Experimental report

23/08/2016

Proposal: 1-01-142 **Council:** 10/2014

Title: Precipitation kinetics in a directstrip casted steel

Research area: Engineering

This proposal is a new proposal

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Samples: low alloy steel (Fe with 0.8%Mn, 0.2% Si, 0.15% C and 0.1%Nb)

Instrument	Requested days	Allocated days	From	To
D11	0	4	17/09/2015	21/09/2015
D33	3	3		

Abstract:

Direct strip casting (DSC) is a promising emerging processing technology for steels which may save up to 90% energy. For conventionally prepared precipitation strengthened steels, precipitation occurs during the hot rolling process in a controled manner. This proposal aims at understanding the precipitation kinetics in DSC processed steels. In particular, we plan to study: 1) the influence of the cooling rate and 2) the kinetics of precipitation during a post-casting heat treatment. The fine scale of the precipitates (up to 10nm) and the relative chemical inhomogeneity of the materials necessitates a large volume of analysis together with an outstanding spatial resolution. SANS is the only precipitate microstructure characterisation technique offering these two .features. The samples will be prepared ex-situ and analysed under saturating magnetic field to exploit the strong magnetic scattering contrast between the precipitates and the ferromagnetic iron matrix.

Precipitation kinetics in a direct strip casted steel

Proposal 1-01-142

Authors: Frederic De Geuser, Thomas Dorin, Alexis Deschamps

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Experiments were conducted on beamline D11 from 17/9/2015 to 21/9/2015

This experiment consisted in measuring both the nuclear and magnetic scattering signal from Cu-rich precipitates in 3 steel compositions aged ex-situ at 3 different temperatures for 5 different durations. The samples were aged in two pre-strained conditions, the first condition consisted of non-strained specimens and the second condition consisted of specimens cold rolled 50%. This totals to a number of samples of 90 samples. The compositions of the samples investigated are reported in Table 1. The samples were prepared with the rapid solidification technology of direct strip casting which allows to retain a significant amount of Cu in solid solution. Composition 1 to 3 are low C steels with Cu contents of 0wt%, 2.5wt% and 5wt%.

Table 1: compositions of the studied direct strip casted steels in wt%.

Wt%	Fe	C	Si	Mn	Cu
Compo 1	bal	0.1	1.5	1	0
Compo 2	Bal	0.1	1.5	1	2.5
Compo 3	bal	0.1	1.5	1	5

The experiments were conducted under a magnetic field which was optimised at the start of the beamtime to be at the magnetisation saturation of the steel samples. Following the commissioning experiments, the strip cast specimens were measured at three sample-detector distances. The samples were systematically normalised by the thickness of the specimens. An example of the 2D scattering pattern obtained is shown in Fig. 1. The scattering patterns display a strong anisotropy which comes from the combined nuclear and magnetic contributions to the scattering signal.

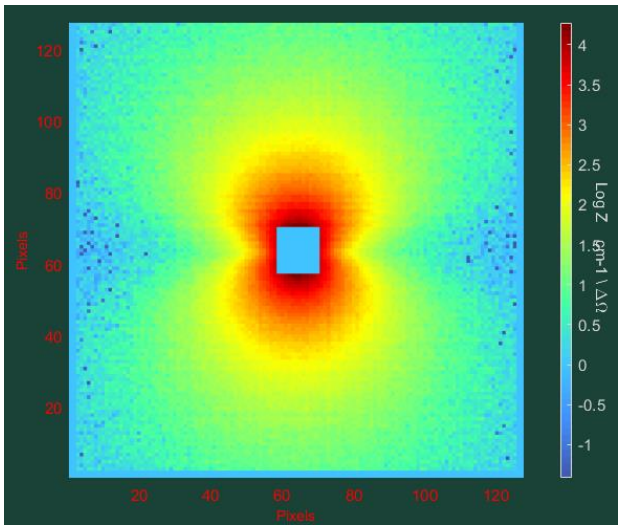
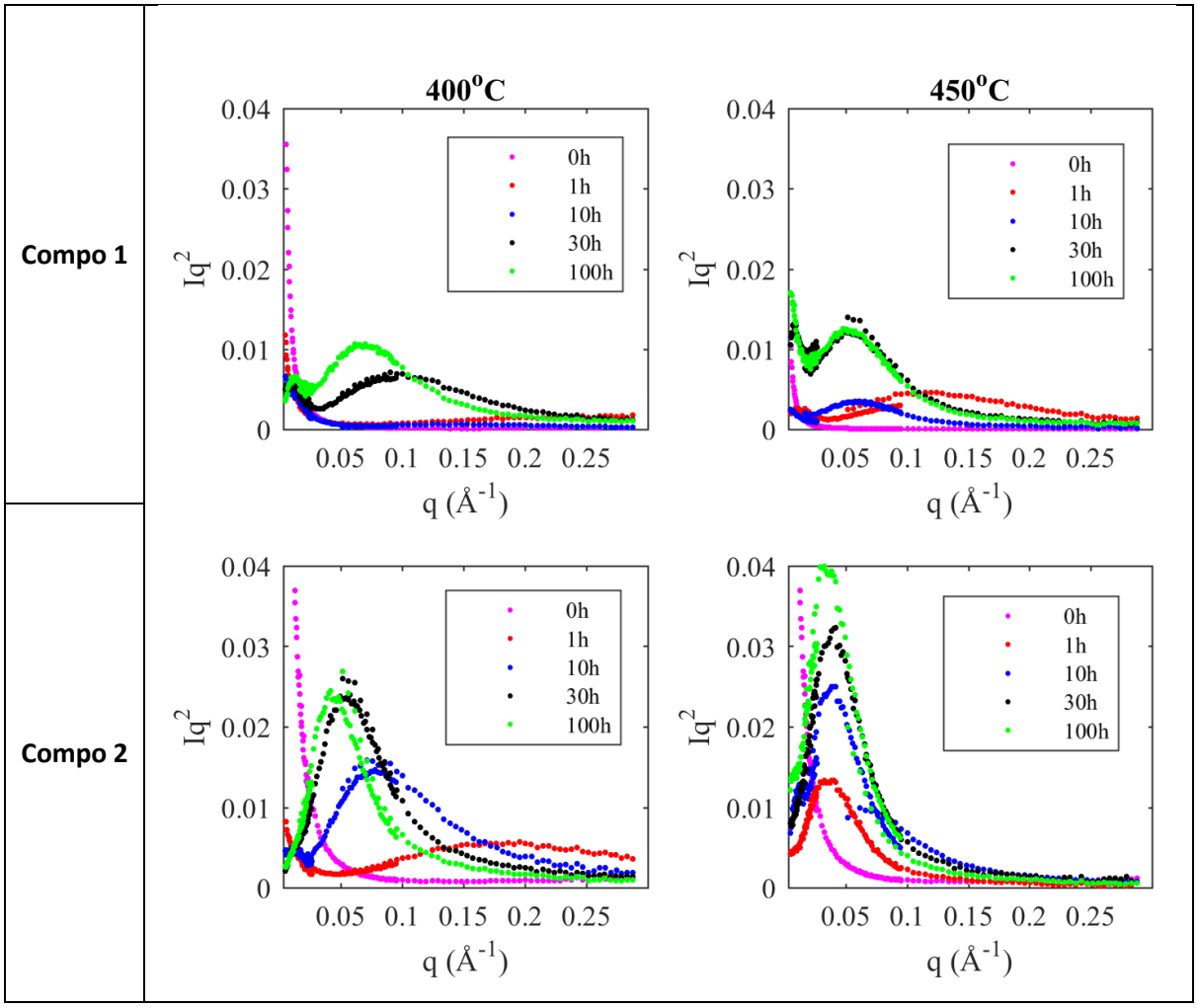


Figure 1: 2D scattering pattern highlighting the anisotropic shape resulting from the magnetic scattering contrast.

The data were then reduced by using the GRASP software provided by the beamline. During the reduction process, a background correction is applied and the transmission is also accounted for.

The data are then reduced by radial integration to obtain a 1D plot of both the nuclear and magnetic scattering intensities. As an example, the 1D scattering signal for different time of aging at two temperatures and for two compositions are shown in Fig. 2.



The data will then be analysed to obtain the size and volume fraction evolution of the precipitates. These data will be computed for all temperatures, compositions and straining conditions, thus creating a significant database of precipitate distribution. These data will be used to better understand the stress increment related to the Fe-Cu phases which is still under debate in the literature. To achieve these outcomes, all 90 samples are currently being mechanically tested. These results will be translated in at least one peer reviewed scientific journal.

These data will also be complemented with atom probe tomography and transmission electron microscopy to investigate the impact of composition and thermos-mechanical conditions on the precipitates' composition at peak age. These results will result in a second publication.

This experiment was a success and will lead to a better understanding of precipitation phenomena in non-equilibrium direct strip casted samples.