Magnetic field processing of steels: from ferrite stabilisation to grain refinement

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In order to evaluate thermo-magnetic processing as a new technology for developing novel microstructures in steels and properties unattainable through conventional processing, the magnetic field effect on a thermodynamic equilibrium is first considered in this presentation. In particular, the effect of magnetic field on the austenite to ferrite phase equilibrium is quantified both experimentally and from calculation. The stabilisation of the ferrite phase is demonstrated in several cases. As a direct consequence of this thermodynamic effect, the field effect on ferrite nucleation is studied.

In a second part of the presentation, two examples of applications related to the benefit of high field processing are given.

Grain size refinement is a well-known and particularly effective mechanism to increase the elastic limit of steels (Hall-Petch law) while improving their tenacity. In automotive applications, the production of steels with ultrafine grains would lead to a significant lightening of the vehicles while keeping a high level of yield stress and tenacity. In this work, it is suggested that the magnetic field can promote ferrite nucleation and thus lead to grain refinement.

Duplex stainless steels are high strength and corrosion resistant steels extensively used in the chemical and petrochemical industry. The best mechanical properties and corrosion resistance are obtained with a microstructure composed by equal parts of ferrite (α) and austenite (γ) and free from other phases, which may lead to a decrease in toughness. The magnetic field is used to avoid the precipitation of the sigma phase, one of the deleterious phases in duplex stainless steels.