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DETERMINATION OF PHASE EQUILIBRIA IN THE FE-C-MN-AL ALLOYS FOR DUPLEX STEELS 3RD GENERATION

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To contribute to CO2 emissions reduction, a 20 % lightening of automotive weight must be achieved. One of the most promising solutions is the development of a 3rd generation of Fe-Mn-Al-C alloys with duplex structure. These steels possess high-strength and high formability.

As a first step, the knowledge of the corresponding quaternary phase diagram serves as a roadmap in the choice of the compositions and the optimization of the elaboration conditions. A thermodynamic database, reliable and precise, is therefore required. However, the literature data on the quaternary system Fe-C-Mn-Al, in the considered domains of composition, are limited.

The requirement is to obtain an accurate characterization of the phases in equilibrium, typically ferrite (α), austenite (γ) and carbide $(Fe,Mn)_3AlC$ (κ), their compositions and proportions with an approach coupled by specific experiences and by calculations thermodynamics. To determine the annealing duration for the establishment of the thermodynamic equilibrium at the desired temperature, the development of phase composition is studied for Fe-0.2C-5Mn-2Al (mass%) at 800°C between 2 min and 4 months. A kinetic model (DICTRA) is proposed to support the experimental evolution of phase fractions and compositions.

Fig.1 shows the evolution of ferrite and martensite phase fraction of this alloy as a function of annealing duration at 800°C. There is no significant evolution of the phase composition by increasing time from 17 to 30 days, evolution also confirmed by EPMA measurement of composition in each phase. Thus the minimum annealing duration for the establishment of the thermodynamic equilibrium at a temperature of 800 ° C is considered to be attain after 17 days (stabilization of the composition and phase fraction).

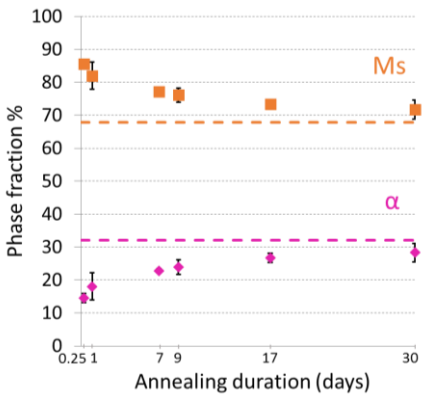

Figure 1: Evolution of ferrite and martensite phase fraction of Fe-0.2C-5Mn-2Al alloy as a function of annealing duration at 800°C. Experimental data (symbols) in comparison with the calculated equilibrium values (dotted lines: database PrecHiMn-03, coll. B. Hallstedt).

In the same way, some selected alloys are characterized, by using X-ray diffraction (XRD), scanning electron microscopy (SEM), field emission gun scanning electron microscopy (FEG-SEM) and electron probe microanalysis (EPMA-WDS), between 700 and 1000°C to specify the areas of stability of γ and κ by the characterization of the α/γ, α/κ, α/γ/κ tie-lines.