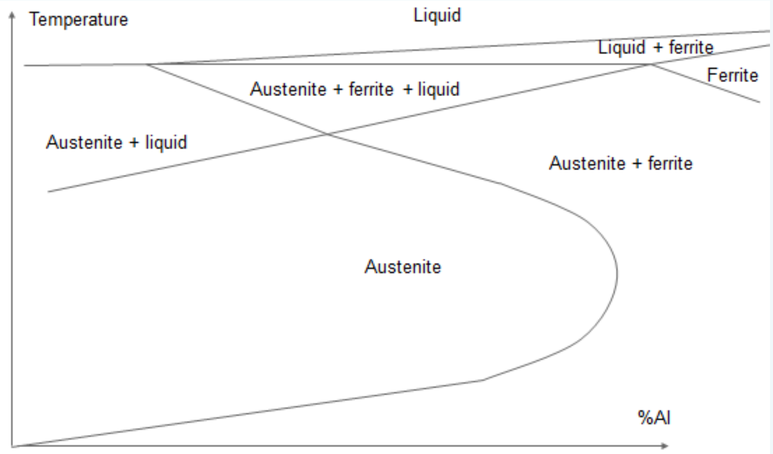
Subject of the MapMod specialised master's degree in 2023

Date	May 22, 2023
TITLE	Kinetics of phase transformations in welded steels
Project acronym	KIFE
Image (recommended)	
Caption of the image	Phase diagram for a steel used in automotive applications as a function of its aluminium content
Thesis work description	In response to automotive manufacturers to make lighter vehicles, ArcelorMittal proposes and develops innovative steels for hot stamping processes. Usibor® and Ductibor® are delivered with an aluminium-silicium coating. Usibor® (composition max Fe – 0.25 wt% C – 1.4 wt% Mn – 0.35 wt%) is a steel formed at high temperature for structural and security parts of the vehicle. Their mechanical properties are extremly high, leading to lighter parts of the order of 30% compared to conventional alloys. The assembly is done by laser welding. The chemical composition in the melted zone is a mixture of two materials plus their coatings. A liquid phase is created by local melting. The solidification microstructure and the thermodynamic phases formed are function of the cooling rate and the chemical composition. In this context, the amount of aluminium in the melt pool is a key parameter to understand the phase transformations and the microstructures that control the final properties of the weld.
Type of project / Project partners	Industrial contract with ArcelorMittal Montataire
Objectives	For low content of aluminium, the phase diagram, established in the hypothesis of full thermodynamic equilibrium, shows the formation from liquid state of the austenitic phase, later forming a fine martensitic microstructure. When the composition in aluminium increases, a coarse granular ferritic microstructure and intermetallic phases are formed, with deleterious effects on the mechanical properties. Aluminium also plays a role on hot tearing taking place during solidification.

	The objective of the project is to study the role of aluminium as well as of other chemical elements on the presence of the austenitic and ferritic phases. The numerical tools PhysalurgY developed at CEMEF will be used [1]. Coupled with CALPHAD databases through the software Thermo-Calc, they predict the domain of existence of the phases. The role of the velocity of the growing interfaces (of the order de 0.1 m s^{-1}) will be accounted for to build kinetic phase diagrams [2] with the goal to understand how to get rid of the ferritic phase during solidification as well as during heat treatments. The simulation results will be evaluated by comparison with cartographies of chemical elements provided by ArcelorMittal.
Reférences	[1] http://physalurgy.cemef.minesparis.psl.eu/ [2] C. Hareland, G. Guillemot, Ch.-A. Gandin, P. W. Voorhees, Acta Materialia 241 (2022) 118407.
Thematic / Industrial Field	Transportation
Key-words	Simulation, Thermodynamic, Welding, Solidification
Skills and abilities requested	Engineer or master
Gross annual salary	
Location	CEMEF, Sophia Antipolis, France ArcelorMittal Global Research and Development Montataire, France
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