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Effects on the Final Mechanical Properties by Soft Annealing 22MnB5 Steel Sheets Prior to Austenitization

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Abstract

Using two different versions of a cold rolled steel, the effect of the initial microstructure on the final mechanical properties were studied. Prior to austenitisation and cooling, half of the cold rolled material underwent a soft annealing treatment to modify the initial microstructure. From these two initial materials, tensile samples were produced to assess the mechanical properties, and the variations in these properties caused by the altered initial microstructure. The samples were isothermally austenitised at 930 °C using a Gleeble 3800 Thermo-mechanical Simulator, followed by cooling at either 5 or 15 °C/s and finally a bake hardening treatment at 170 °C for 20 min. The tensile testing was performed at room temperature using notched tensile samples, where the deformation was measured using both an extensometer and digital image correlation.

The tensile testing revealed that the cold rolled samples, without any initial heat treatments, were stronger and less ductile than the soft annealed equivalent. The difference in strength was most pronounced for the higher cooling rate, and the difference in ductility was most apparent for the samples cooled at a lower rate. In the samples cooled at 5 °C/s, the final microstructure was composed of mainly ferrite and pearlite. The morphology differed between the two different materials, with the soft annealed samples having smaller regions of pearlite, and the ferrite grains containing carbides. The faster cooling rate, 15 °C/s, produced a microstructure containing mainly bainite and martensite, with smaller regions of ferrite.

Measurements of the parent austenite grain size revealed a larger average parent austenite grain size for the samples which were soft annealed prior to austenitisation, both at the beginning and at the end of the isothermal austenitisation. This is one of the parameters which can affect the phase transformations kinetics, as the grain boundaries act as nucleation sites during austenite decomposition. Thus, a smaller parent austenite grain size could be expected to lead to a softer microstructure formed earlier during the cooling. However, this was not true for the tensile testing performed as part of this study. The initial microstructure affects the final microstructure and mechanical properties in a manner not captured by simplified models using the average austenite grain size and chemical composition.

Introduction

Modelling of press hardening production processes are important to reduce cost, increase the rate of design iterations and to manage risks. The production lines are well suited for continuous production of large volumes and might not be ideal for the production of physical prototypes. This has led to the development and use of advanced simulation tools to digitally assess the production feasibility, resulting part geometry and mechanical properties. The use of digital tools enables a continuous assessment of the final product, where both the part itself and the production process can be adjusted. To describe this process numerically, with reasonable accuracy and speed, the effect of various process parameters must be understood. One example of this is the effect of the initial microstructure on the production process and subsequent properties of the final component.

The microstructure of a steel after austenitisation and subsequent cooling to room temperature is an evolution from previous states, a process that can be traced back to the initial production of the steel. During the manufacture of steel sheets there exists rolling steps wherein the material is reduced in thickness after the continuous casting. One major factor influencing the microstructure after this rolling operation is the temperature at which the final steps are performed: hot rolling and cold rolling of steel sheets produce their own characteristic microstructure. Further processing can include heat treatments to modify the microstructure and the mechanical properties of the material. Soft annealing is an example of this, where the aim is to reduce the