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Microstructural development and mechanical properties during hot rolling and annealing of an automotive steel combining TRIP/TWIP effects

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Highlights

- It was demonstrated that the microstructure consisted of ferrite and austenite after hot rolling.
- Austenite content decreased for 20 min, then increased for 2 h and finally decreased for 6 h.
- Hot rolled sample exhibited the highest yield and tensile strength.
- Hot rolled and annealed sample exhibited the highest elongation and impact energy.

- Hot rolled sample exhibited only TRIP effect while hot rolled-annealed displayed TRIP-TWIP effect.

Abstract

This research was carried out in order to study the variations of microstructure and mechanical properties of 9 wt% Mn steel, which was produced by ingot casting, hot rolling and intercritical annealing (IA). Thermodynamic simulation of the corresponding phase diagram for the experimental composition allowed to select a suitable intercritical annealing temperature of 680 °C. After this step, we found a microstructure composed by lamellar ferrite within an austenite matrix. Austenite content was 47% for the hot rolled sample, while it was 36% and 52% for two and 6 h of intercritical annealing, respectively.

Unfortunately, austenite phase started to coarsen at 6 h and ferrite lamellas were also fragmented, causing an important hardness and elongation reduction. Mechanical properties were measured comparing hot rolling samples vs. annealed samples at 680 °C for 2 h. We found that an excellent combination of UTS (ultimate tensile strength) of 1200 MPa, an elongation of almost 60% and an impact energy of 55 J could be obtained after IA for 2 h. These results, with the exception of UTS, significantly exceeded the values displayed by hot rolling condition and were associated with the stability of austenite which increased during annealing. Finally, we demonstrated that only TRIP (transformation induced plasticity) effect was present in the hot rolled sample during tension testing, in contrast with the annealed sample in which austenite content only diminished 12%, which indicates that TWIP (twinning induced plasticity) effect was also effective.

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Keywords

Metals and alloys; Mechanical properties; Microstructure; Scanning electron microscopy

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