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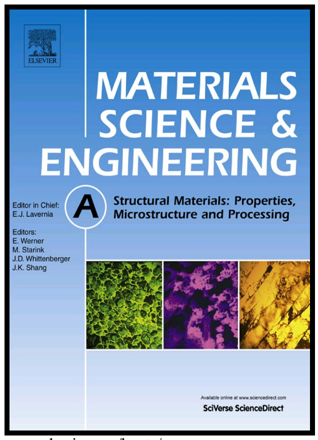

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Influence of the Prior Athermal Martensite on the Mechanical Response of Advanced Bainitic Steel

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Abstract
The accelerated formation of bainite in presence of martensite is opening a new processing window for the steel industry. However, for a feasible industrial implementation, it is necessary to determine the mechanical behaviour of the steels developed under such conditions. This study focuses on analysing the effects of the formation of athermal martensite, followed by the formation of bainitic ferrite, on the mechanical response of a low-C high-Si steel. For this purpose, microhardness measurements and tensile tests have been performed on specimens that were thermally treated either above or below the martensite-start temperature (M_s). Specimens isothermally treated below M_s exhibit a good combination of mechanical properties, comparable with that of the specimens heat treated by conventional treatments above M_s, where there was no prior formation of martensite. Investigations show an increase of the yield stress and a decrease of the ultimate tensile strength as the isothermal holding temperature is decreased below M_s. The formation of prior athermal martensite and its tempering during the isothermal holding leads to the strengthening of the specimens isothermally heat treated below M_s at the expense of slightly decreasing their strain hardening capacity.

Keywords: multiphase steels, mechanical response, isothermal treatments, prior athermal martensite, bainitic ferrite, strengthening mechanisms.

1. Introduction
Steel industry aims to develop steels with a better balance of mechanical properties through more efficient, cost-effective, and sustainable manufacturing processes. Particularly, obtaining bainitic microstructures by the application of isothermal treatments below the martensite-start temperature (M_s) is now one of the most promising processing routes within the steel sector. This is due to the accelerating effect of the partial formation of martensite on the subsequent bainitic reaction [1-7]. These thermal treatments involve an isothermal holding below M_s after an interrupted cooling. Adequate cooling rates and alloy compositions are used to avoid the formation of ferrite, pearlite or bainite during cooling from austenitization. Bainitic ferrite forms from the untransformed austenite during the subsequent isothermal holding below M_s [6-10]. Finally, the remaining austenite will either be retained or transform into fresh martensite during the final cooling to room temperature. A multiphase microstructure is thus formed in which specific fractions of martensite and bainite coexist with carbon-enriched retained austenite.
These multiphase microstructures are comparable to the ones present in carbide-free bainitic (CFB) steels and quenching and partitioning (Q&P) steels. These steels are also developed through thermal cycles in which an isothermal holding around the M_s temperature is performed [11-15]. In CFB steels, the phase mixture is generally formed by a bainitic matrix with certain fractions of retained austenite and fresh martensite. In Q&P steels, the primary matrix is martensitic and it is tempered to some extent during the partitioning step. The final microstructure also contains certain fractions of retained austenite and fresh martensite. Regarding their mechanical behaviour, CFB and Q&P steels exhibit a composite mechanical response to the application of stress [13-15]. The relationship between their

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