Perspectives on Maximizing Strengthening Mechanisms in Automotive HSLA Steel

Well-established practices exist for the production of cold-rolled and continuously annealed high-strength, low-alloy (HSLA) steels as both coated and uncoated variants. Through standard processing techniques, the yield strength of cold-rolled HSLA steel is practically limited by numerous process and alloy design factors to 550 MPa and less. A production methodology is proposed to achieve greater strengths in cold-rolled and continuously annealed HSLA steels. This methodology utilizes both increased precipitation of microalloy carbides prior to continuous annealing and a subsequent annealing process in which recrystallization of ferrite is suppressed prior to partial or full austenitizing. The resultant microstructure, as a consequence of enhanced precipitate and grain refinement strengthening, achieves greater strengths than those traditionally produced for automotive applications of cold-rolled HSLA steels. The implications of mass adoption of such enhanced cold-rolled HSLA steels are discussed, including the potential for partial replacement of intermediate-strength advanced high-strength steel in automotive body structures.

Modern automotive structures optimize cost, performance and manufacturability of the constituent components as an assembly for the achievement of both mass and safety targets. Due to the ongoing challenges posed by the implementation of increasingly complex advanced steel grades and the desired cost-performance tradeoff considered on a component-by-component basis, a considerable portion of automotive structural steel production remains microalloyed high-strength low-alloy (HSLA) steels.1 A beneficial combination of low-carbon and low-microalloy additions, i.e., Nb, Ti and V, are needed to generate moderate strengths by grain refinement and precipitation strengthening in HSLA steels. The low-alloy additions, coupled with well-known and predictable metallurgical mechanisms, maintain the relative attractiveness of HSLA application in automotive body-in-white and chassis structures.2 Beyond the steel production concerns, the consistency of the manufacturing response of HSLA steels in both forming and joining is taken as the standard for modern applications. With largely single-phase ferritic microstructures generating correlated local and global formability, the predictions of HSLA steel performance in both forming operation and during impact modeling can be achieved with a high degree of confidence. Microalloyed HSLA steels are, however, limited by the reliance on grain refinement and precipitation strengthening mechanisms relative to advanced high-strength steels (AHSS) in achievable combinations of strength and uniaxial tensile ductility. Based on these well-characterized tradeoffs between HSLA and AHSS steel grade cost, performance, and manufacturability, successful attempts have been made to increase the relative combinations of strength and formability through alternative metallurgical strategies in hot-rolled products. As an example, one such strategy relies on controlled interphase precipitation of microalloy carbides in a low-carbon hot-rolled steel to achieve desirable combinations of increased strength, uniaxial tensile ductility and stretch flangeability.3 Hot-rolled strategies, however, limit the gauge range and tolerance to automotive designers, and a cold-rolled (bare or galvanized) variant of HSLA with increased strength, ductility and flangeability