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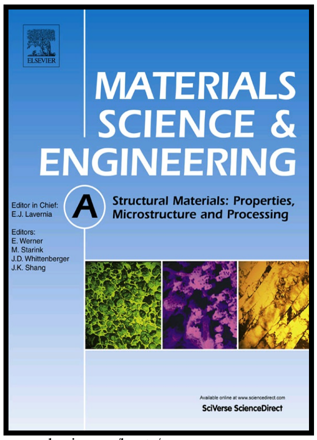

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Deleterious Effects of Nitrogen Annealing on the Mechanical Properties of Medium Manganese Steels

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ABSTRACT
Nitrogen-annealed tensile specimens of a cold rolled medium Mn (9.76 wt-%) steel exhibited significantly reduced ductility due to a two-zone embrittled surface layer, imparted during annealing in a nitrogen atmosphere. The embrittlement was associated with high nitrogen contents at the surface.

KEYWORDS: Medium Mn Steel; Annealing Atmosphere; Mechanical Properties

INTRODUCTION
Medium Mn sheet steels with Mn contents typically between 5 and 12 wt-% have been shown to produce exceptional combinations of strength and ductility characteristic of 3rd generation advanced high strength steels (3GAHSS) [1-5]. The mechanical properties reflect high amounts of retained austenite, typically stabilized by intercritical annealing to partition Mn into austenite. Intercritical annealing temperatures, selected based on alloy content, typically in the range of 400 to 800 °C are used, and employment of a higher temperature is desirable to enhance Mn partitioning by diffusion [6]. Use of a higher intercritical annealing temperature has disadvantages due the fact that Mn can oxidize preferentially at high temperatures forming Mn_2O_3 on the steel surface [7,8]. Furthermore, medium Mn steels often contain Al and Si, elements which are easily oxidized [7-9]. To avoid the unacceptable formation of oxides which are detrimental to mechanical properties as well as further processing (*e.g.* coating the steel substrate) [7], it is essential to use a protective atmosphere during annealing. The present study highlights the importance of annealing atmosphere on the mechanical properties of a 10 wt-% medium Mn steel. Data were obtained on specimens annealed in two different atmospheres, 100% nitrogen and an enclosed environment with the oxygen partial pressure minimized by Ti gettering.

EXPERIMENTAL
The experimental steel containing 9.76Mn-0.16C-1.37Al-0.19Si-0.0025N-0.0018S (wt-%), identified as “10Mn steel,” was laboratory cast as an 11 kg ingot and processed to a final thickness of 1 mm by hot and cold rolling. Longitudinal (tensile axis parallel to the rolling

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