Hot rolled sheet steels are normally supplied to satisfy such customer-defined specifications as yield strength, tensile strength and total elongation. Typically, as yield strength (or yield-to-tensile ratio) increases, relative ductility decreases. Total elongation is also a general measure of formability, with higher elongations generally providing better formability. However, the elongation value is inversely proportional to the thickness of hot rolled sheets.

Boron-added low-carbon steel is recommended for automotive parts because of its excellent ductility. In this steel, boron reduces phase transformation so that the possibility of hot rolling above Ar3 temperature, without loss of ductility caused by mixed microstructure, in the production of thin-gauged steels increases. The potential for boron to increase hardenability is due to its segregation at austenite grain boundaries. This reduces the ferrite nucleation rate during austenite/ferrite phase transformation, which suppresses the formation of polygonal ferrite. However, the mechanism by which boron increases the hardenability is not completely clear. While the effect of boron on tensile strength is known through its influence on hardenability, its influence on the evolution of ferrite morphology and elongation is still controversial.

In this study, the effect of boron addition on the microstructure and mechanical properties for low-carbon steels was investigated in order to clarify the development of ferrite morphology and precipitation behavior as they relate to rolling temperature. In addition, the influence of solute elements (C and N) and hot rolling temperature on the mechanical properties of the boron-added steel is described. Finally, the results of mill trials with the proposed boron-added low-carbon steel are compared to those for conventional formable steel.

**Experimental Procedures**

Experiments were conducted on boron-free and boron-added low-carbon steels with various nitrogen contents, as shown in Table 1. In addition, the results obtained from pilot mill tests were applied to practical rolling with Steel D. Steel E is a commercial-grade formable steel that does not contain boron. The B/N ratio of boron-added steels signifies the ratio of atomic equivalence for boron and nitrogen.

The ingots were vacuum melted in the laboratory and hot rolled to small slabs with a thickness of 30 mm after heating to 1200°C. The slabs were reheated to 1150°C for 120 minutes. After heat treatment, a 7-pass hot strip rolling experiment was performed to obtain 2.6-mm-thick strip, which was then compared with 1.6-mm-thick strip obtained from the practical rolling plant. The final rolling speed was set at 150 mpm (2.5 m/s). The temperature of materials during the rolling test was measured. To confirm the dependence of rolling temperature, the pilot mill tests were performed at different final pass temperatures: 860, 880 and 920°C. After hot rolling, the hot rolled sheets were cooled to 650°C.

An analysis of microstructure was performed by optical microscopy and an image