

8306-083

DEVELOPMENT OF MICROALLOYED MEDIUM CARBON HOT ROLLED BAR PRODUCTS

John F. Held, Barry A. Lauer
Jones & Laughlin Steel Corporation
Pittsburgh, PA

The application of microalloying technology in the production of bar products was initially employed by Jones & Laughlin Steel for cold finished bars. These products are available in a variety of grades with guaranteed strength levels. More recently, hot rolled microalloyed bar steels have found acceptance in a number of applications spanning products with high strength properties produced directly from the bar stock, to air cooled forgings which do not require heat treatment. As is the case for cold finished bars, microalloyed hot rolled bars can be produced with guaranteed strength properties. These properties are a function of the base composition, the type and amount of microalloying addition, the bar diameter and thermal practice. This paper will address each of these factors and describe several commercial applications involving the production of forged parts from microalloyed bar steels.

THE APPLICATION OF MICROALLOYING technology for enhancement of strength properties in bar steels has been practiced for a considerable period of time. Examples of various applications are hot rolled bars having guaranteed strength properties,^{1,2} bar stock for production of air cooled forgings which have guaranteed properties without the need for costly heat treatment,³⁻⁷ and also rough stock for the production of high strength cold finished bars.⁷⁻⁹

The specific properties that can be obtained in microalloyed bar steels are known to be a function of the base chemistry plus the added effects of the type and amount of microalloying addition.¹⁰⁻¹² It is recognized that the properties of the microalloyed bars are further influenced by thermal conditions, such as the rolling or finishing temperature,¹³ and also to some extent by the cooling rate of the bar.^{9,12}

In order to more fully define the relative effects of composition, a number of laboratory bar heats were produced and tested. These heats contained carbon contents of 0.24%, 0.30% and 0.36%. For each carbon level, the manganese content was varied from 1.35% to 0.65%. Within each base composition vanadium contents from 0 to 0.20% were examined, in some cases with a columbium addition of 0.03%, and in some cases with a nitrogen addition of 0.015%. The steels were hot rolled on a laboratory bar mill to 1.7 inch x 1.7 inch squares with a finishing temperature of 1830/1840°F. The materials were evaluated on the basis of tensile properties, hardness and impact strength over a range of temperatures.

TENSILE PROPERTIES - Tensile properties for the hot rolled steels are shown as a function of vanadium content in Figures 1-4. The additional effect of base carbon content on tensile properties is also shown in Figures 1-3, each of which represents a discreet manganese level, while the effect of varying manganese content is shown in Figure 4 at a fixed carbon level. In all cases, both yield and tensile strength increase linearly with increasing vanadium, while both total elongation and reduction in area decrease linearly. Both yield strength and tensile strength increase at a rate of ~1300-2150 psi per 0.01% vanadium for the composition ranges examined. With a given vanadium level the effect of raising the carbon content from 0.24% to 0.36% is to increase yield strength by ~900 psi per 0.01% carbon, and to increase tensile strength by ~1665 psi per 0.01% carbon. The relative effect of manganese variations between 0.35% and 0.65% changes with the vanadium content as illustrated in Figure 4. For example, at the 0.10% vanadium level, the relative effect of manganese is to increase yield strength by ~135 psi and tensile strength by ~365 psi per 0.01% manganese. However, at the 0.20% vanadium level yield strength is increased by ~300 psi and tensile strength by ~665 psi per 0.01% manganese.