

Properties of Low Carbon Steel with Various Microalloying Additions after Particular Thermomechanical Processing

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Abstract

The article deals with production of the micro alloyed steel forged products for oil industry. Customer requires high toughness in lowered temperatures, guaranteed weldability and also relatively high yield strength. Applied heat of steel has 0.1 of carbon content and 1.5 percent of manganese. Conventional alloying with conventional heat treatment not always lead to consistency in mechanical properties. Application of usual heat treatment (quenching and subsequent tempering) ensures only close compliance of requirements in yield strength. It is also complicated to meet adequate toughness at -46°C by applying conventional heat treatment. New heats with combination of several microalloying elements (Ti, V, Nb, Zr) were prepared. Physical simulation of forging on real specimens was done on unique device with possibilities of temperature and deformation controlling. The main goal of this experiment was to assess mechanical and microstructural properties of steel after addition of various amounts of various microalloying elements.

Introduction

High-strength low-alloy (HSLA) steels, or microalloyed steels, are designed to provide better mechanical properties and/or greater resistance to atmospheric corrosion than conventional carbon steels. They are not considered to be alloy steels in the normal sense because they are designed to meet specific mechanical properties rather than a chemical composition. In order to realize the full strengthening potential of microalloying additions, it is necessary to use a soaking temperature prior to forging that is high enough to dissolve all vanadium-bearing precipitates. [1]

A soaking temperature above 1100°C (2010°F) is preferred. For Nb-Ti microalloyed steel the single step austenite reheating temperature at 1150°C provided better austenite conditioning than the higher reheating temperature at 1240°C [2]. According to [3] and [4] complete dissolution of carbonitride precipitates based on Nb occurs at 1140°C respectively in interval between $1100 - 1200^{\circ}\text{C}$. [5]

Further processing after austenitization should consist of two phase forging. A higher amount of deformation at elevated temperature (ca 1100°C) facilitates dynamic recrystallization. In this stage a critical amount of strain is required for austenite grain refinement through repeated recrystallization. The second stage should be carried out below 900°C i.e. below recrystallization temperature (TR) with an intention of making the austenite grain pancaked and to introduce interfacial defects in hot austenite. These interfacial defects in turn lead to an increase in effective grain boundary areas and enhances the nucleation potency of ferrite. Subsequently, the microalloying elements come out of solution with decrease in temperature, which inhibit

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