

Thermomechanical Study of H13 Hot Forged Bars

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ABSTRACT

H13 is a hot work tool steel used as extrusion and forging dies in metal forming industries. It is characterized by its high thermal stability and wear resistance. This alloy is generally produced by hot forging of large size cast ingots. However, the selection of the hot forging parameters significantly influences the evolution of the microstructure, and hence the final properties, as well as the formability of the alloy, which may lead to surface cracks and internal defects during forging. In the present work, a thermomechanical study of H13 was conducted to quantify the impact of different deformation conditions on microstructure evolution and to better understand the characteristics of this steel. Specifically, the kinetics of grain growth and carbide dissolution at different forging temperatures were determined. Then, hot compression tests enabled the modeling of stress strain curves for the purpose of implementation in a simulation software.

Key words: H13, Forging, Grain growth, Carbide dissolution, Modelling

1. INTRODUCTION

Open die forging consists of compressing a piece between a set of dies for a series of blows to achieve a desired shape. Along with dimensioning, hot forging of cast ingots has many other important roles: breaking down the cast microstructure, closing internal porosities, redistributing the segregated elements and refining the grain size. These major microstructural changes are achieved through a complex thermomechanical cycle that consists of heating the piece at temperatures well above 0.6T_m (melting point), and applying an adapted sequence of compressive forces that could include up to 200 blows.

H13 is a hot work tool steel used as extrusion and forging dies in metal forming industries. It is characterized by its high thermal stability and wear resistance due to its high content of alloying elements and second phase particles. The alloy is generally produced by hot forging of large size cast ingots. Finkl Steel – Sorel produces bars of various alloyed steels and sizes, from 250 to 1060 mm diameter. While their standard forging procedure produces perfectly sound bars of low-alloyed steels such as 4340, sometimes sections of H13 forged bars present small voids along the centerline. The hot forging parameters were analyzed; however, no obvious cause was identified. In search for a consistent solution for this problem, an in-depth study was undertaken to investigate the thermomechanical processing of H13, simulating the actual hot forging process and quantifying the impact of different deformation conditions on microstructure evolution and defect generation or removal.

From a purely microstructural perspective, when soaking the material at high temperature before forging, grain growth occurs. Meanwhile, precipitates dissolution takes place at different temperatures. For example, Chromium carbides dissolve around 788 °C while Vanadium carbides dissolve around 1279 °C (V₈C₇) and 1174 °C (VC), and Molybdenum carbides dissolve around 1050 °C per Gibbs free energy equations (Ning, 2017). Those transformations highlight two important characteristics of the material that influence the stress distribution and effectiveness of consolidation during subsequent deformation: