Analysis of the Effects of Reduced Oxygen Atmospheres on the Decarburization Depths of 300M Alloy Steel

by

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the degree of

MASTER OF SCIENCE

Major Subject: MATERIALS SCIENCE AND ENGINEERING

The original of the complete thesis is on file
In the Rensselaer Polytechnic Institute Library

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Troy, New York

July 2010
(For Graduation August 2010)

ABSTRACT

The influence of temperature and atmospheric oxygen concentration on the depths of decarburization (the kinetic process in which carbon diffuses from the near surface region in carbon-containing metals) is investigated in the following study. Samples of forged 300M steel alloy were purposely decarburized for two hours at 800, 900, and 1000 °C, each in air, 14% O_2 with a balance of nitrogen, and 7% O_2 with a balance of nitrogen. The complete decarburization (ferrite) depth was estimated using a visual estimation and software estimation method. Samples were then hardened via austenitization at 1000 °C for 30 minutes in a 1.33×10^{-5} Pa vacuum and immediately quenched in water to enhance the hardness gradient, which is directly related to the carbon concentration profile. A Vickers microhardness indentation test was used to produce such hardness gradients and allowed estimation of the total decarburization depth, that is, the depth from the surface which is adversely affected by decarburization. These depths were then compared to values predicted from error functions with and without the incorporation of the oxide layer (scale). An algorithm specific to these conditions and material was produced, allowing input of time, temperature, and atmospheric oxygen content.

As predicted in the literature, atmospheric oxygen concentrations of these amounts were ultimately concluded to have no major effect on either complete or total decarburization depths and temperature had the most pronounced effect. However, the oxide layer was found to decrease in both the 14% and 7% O_2 conditions at all temperatures, which the literature predicted would not occur until very low partial pressures of oxygen. Further, this reduced scale depth did not increase decarburization, indicating the diffusion of carbon monoxide through the oxide layers was not a rate limiting step.