Real-time Kinetic Model for the Evolution of the Phases during the Quenching of Steel Balls

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Abstract

The locus of the micro-structural phase boundaries and their respective volumetric fraction during the quench of the austenite steel critically determines the resulted physical and mechanical properties. Both dynamic numerical and analytical frameworks are developed, combined with the experimental measurements, for predicting the real-time formation of the equivalent phase borders and their marginal evolution within the steel ball. In this regard, the transient behavior of the temperature is computed upon quenching where the threshold of phase transformation, obtained from our experimental data, is tracked as the locus of the earliest formation of phase boundaries. Our parametric analysis predicts the role of the quench temperature, scale (i.e. radius) of the steel ball and the initial temperature and additionally anticipates the onsets, where one and two of the phases cease to exist. The model could get utilized for the designing the quench parameters to obtain the desired mechanical properties from the original austenite state.

Keywords: Quench, Phase transformation, Real-time Evolution, Numerical Modeling, Analytical Development.

1 Introduction

Quenching is process used mainly to harden the steel by undergoing martensite transformation, where high temperate austenite steel is rapidly cooled down through its eutectoid point, resulting in the destabilization of austenite [1, 2]. This is a typical method resulting in the production of martensite steel [3] and the proper thermal treatment is needed to obtained the desired mechanical properties [4, 5].

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