Influence of Mould and Insulation Design on Soundness of Tool Steel Ingot by Numerical Simulation

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Abstract-- **Solidification of cold work tool steel ingot Type X210Cr12 is simulated by MAGMA software. In current study in order to produce sound ingot, a new 2.8 ton ingot mould designed which include some changes in mould parameters such as ingot height, mould slope, slenderness ratio, mould concavity radius, fillet radius of mould internal corners and feeding diameter to ingot upper diameter ratio. Furthermore, the effect of insulating between kokil and feeding ring and also the outer surface of feeding ring as well as one third of upper part of kokil outer surface on centerline porosity formation according to Niyama criteria were investigated by solidification modeling of 2.8 ton and 4.4 ton ingots.**

Keywords-*: Numerical modeling, steel ingot, mould parameters, porosity.*

I. Introduction

Porosity in castings contributes directly to customer concerns about reliability and quality. Controlling porosity depends on understanding its sources and causes. Significant improvements in product quality, component performance, and design reliability can be achieved if porosity in castings can be controlled or eliminated [1]. Many of researchers studied on internal defects in steel ingots [2-5]. Balcar et al. [6] investigated the influence of ingot shape on casting and solidification processes of a 9 ton tool steel ingot with respect to real condition to suppress ingot internal discontinuities and obtaining an acceptable level of structural and chemical homogeneousness. Kermanpour et al. [7] numerically simulated influence of mould and casting parameters such as slenderness ratio, pouring rate, isolate shape and mould slope on solidification of heavy forging ingot of low alloy steel. On the basis of their numerical model results, pouring the melt under a constant rate, lower slenderness ratio, using of circular cross section for the hot top and increasing the mould slope is preferred to enhance vertical solidification and to reduce transverse solidification in the hot top region. Guang-min et al. [8] modeled mould filling process and solidification process by a primary casting method for steel ingot mold and then improve the casting method design to prevent effectively the defects such as the sand inclusion, slag inclusion, shrinkage porosity and cavity. Zhang pei et al. [9] investigated the influence of optimization of casting parameters involved casting temperature, pouring velocity and interface heat transfer to decrease shrinkage pore and microporosity. Tashiro et al. [10] analyzed Influence of hot top and mould design on the formation of central porosities and loose structure in heavy forging ingot. They compared the results of the analysis with those of sectioning investigation of 100 and 135 tons ingots. The cold work tool steel type X210Cr12 is very sensitive to internal discontinuities such as porosity and carbide formation. So after ingot casting, it should be refined by ESR process. In this paper a new design for ingot mould was applied to produce a sound ingot and eliminate ESR process which will be very economical. Niyama criterion was used to predict porosity formation during solidification of ingot. In new design, Changing in mould parameters such as ingot height, mould slope, slenderness ratio, mould concavity radius, fillet radius of mould internal corners and feeding diameter to ingot upper diameter ratio and insulating between kokil and feeding ring and outer surface of feeding ring as well as one third of upper part of kokil outer surface cause in production of a sound ingot with a Niyama value greater than critical Niyama factor.

II. Analytical procedure

Ingot solidification was calculated by F.V.M. method in MAGMA software. From the database of MAGMA the steel type X210Cr12 was selected which its chemical composition is shown in table1. The kokil mould, stool plate and feeding ring