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Developing an Intelligent Quantitative Slab Centerline Segregation Estimator in Steels

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ABSTRACT

Steel slab centerline chemical segregation is an important quality control parameter for critical applications such as oil and gas pipelines, pressure vessels, heavy structural components. Prevalent qualitative estimation tools don't provide ample insights into internal homogeneity of finished rolled products and hence a more quantitative estimation of centerline segregation has been attempted using image analysis software developed in house. Application and usage of this simple estimator tool for geometrical segregation quantification will be discussed in this article.

Keywords: Steel Slabs, Centerline segregation, macroetching, classification, Mannesmann

INTRODUCTION

Steel slab centerline chemical segregation is a natural process during solidification of steels due to low melting point of the last alloy-rich solidifying melt. The segregation is prominent for higher carbon and alloy rich melts. The segregation affects mechanical properties, soundness as well as weldability properties of steel. For advanced critical applications such as pipelines for oil and natural gas transmission, storage and pressure vessels, pressurized tank cars, it is critical that the steel poses sufficient toughness at low temperatures and hence centerline segregation should be at its minimum [1,2]. Centerline segregation is integral to whole body toughness of components.

In order to eliminate or to minimize centerline segregation in steel slabs, metallurgists have innovated low-carbon, low-alloy steel chemistries and processing that meets stringent mechanical properties. On the other hand, steel manufacturers have resorted to technological installations such as dynamic soft reduction which contain or minimize segregation to a large extent [3].

There are metallographic methods ASTM E381 [4] to reveal chemical segregation in cast steel sections and segregation is examined by macroetching a full width, full thickness slab section cropped transverse to casting direction. The centerline chemical segregation is then compared with a classification rating system indicated by Mannesmann [5] and is universally accepted as a benchmark classification system for acceptance by end users. Mannesmann classification system for segregation is based on a qualitative comparison of segregation intensity and distribution along the centerline of cast slab cross section with that of the standard charts and the classification based on four distinct segregation intensities as shown in Figure 1.

The comparison and thereby classification is entirely based on visual comparison and not subjected to geometric calibration or quantification, therefore, utterly subjective. Today, all pipe manufacturers require a centerline segregation rating of 2 or better as per above qualification rating for acceptable quality criteria of steel for downstream processing. Ironically, most of the steelmakers falter in assigning a distinct rating when it comes to a segregation pattern resembling an upper side of 2 or lower 3. The indecision is further aggravated by poor light, low resolution macrographs, obscure etching and poor eyesight.

Several earlier research has attempted [6, 7] to assign a quantitative estimation of centerline segregation so that a quantitative rating system could be evolved based on density of segregation per unit length/area/volume of metal. Spectra Energy Inc has earlier evolved a rating guideline [8,9] based on quantitative measurement of segregation spots along the centerline of slabs and assigning a rating based on a logical matrix consisting of size and number of segregation spots. This guideline though

