PAPER

Geometry based and simulation supported porosity prediction in ductile iron casting

Amit Sata, Nikunj Maheta, Anjali Dave and Himanshu Khandelwal

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Abstract

Shrinkage porosity is one of the significant challenge in metal casting process that influence productivity and energy efficiency particularly with castings that are not produced as per the requirement of Original Equipment Manufacturers (OEMs). To address this issue, proactive measures and predictive techniques are essential. Among these, the criterion function stands out as an important empirical model widely explored in the literature. It intricately connects solidification process to the development of shrinkage porosity by considering the key variables such as molten metal velocity during solidification, cooling rate and thermal gradient to offer predictive insights into the position and existence of porosity. It is necessary to establish a criterion function that takes into account the impact of geometric variation on the degree of

shrinkage porosity. In this paper, a geometry-based quantitative prediction model for ductile iron castings was developed using a standard shape of a casting with three T-joints. By correlating actual experimental data with solidification simulation results, meaningful insights were obtained and extrapolated. The resulting quantitative prediction model that incorporates the effects of geometric variation has been validated and provides better prediction of shrinkage porosity.

Introduction

Metal casting is an extremely versatile manufacturing process used to produce simple to highly complex industrial components. A total of more than 45,377 foundries across the world producing around 110 million metric tons castings annually. Nearly 21% of these castings are produced using ductile iron. Across the globe, India is the second-largest manufacturer of metal castings producing nearly 11.4 million metric tons each year [1]. However, 7.5% of the industrial castings produced in these foundries are either rejected or recycled due to numerous defects. One of the key concerns for casting manufacturers is the existence of shrinkage porosity in metal castings [2]. Porosity is the term given to interconnected or clustered and an irregular shape corresponding to the shape of the interdendritic region. The development of porosity due to solidification shrinkage commonly referred as a shrinkage porosity poses a significant concern in the metal casting process. Shrinkage porosity and related defects in casting are major cause of casting rejections and rework in the casting industry.

A few industrial castings with occurrence of shrinkage porosity are represented in figure 1. It was observed from figure 1 that the size and location of shrinkage porosity vary based on the thickness and shape of the industrial casting. This phenomenon is often considered undesirable as it negatively impacts the mechanical properties of cast components [3–5]. Therefore, mitigating shrinkage porosity is crucial for ensuring the quality and performance of castings in various industrial applications.

Figure 1. Presence of shrinkage porosity in industrial castings.