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A Literature Survey Of Methods To Study And Analyze The Gating System Design For Its Effect On Casting Quality

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Abstract

For the optimum design of gating system, the study of filling process is of great significance since it directly affects casting quality. The goal of proper mould filing cannot be achieved without proper gating design which influences the flow pattern, further affects the temperature distribution and modifies the progression of solidification. But it is not only expensive but difficult to observe the molten metal flow in the mould directly due to the opacity of sand mould.For the study and analysis of flow of molten metal through the gating system and into the mould cavity, many researchers have tried various techniques which can be broadly classified as direct observation method and through modelling the process by water analogy or by computational modelling.To get accurate and dependable prediction of the subtle transient events, one has to make a judicious combination of both methods for casting with an alloy system. Many researchers attempted to use numerical simulation techniques to analyse the molten flow through the gating system, which has an advantage to accurately predict subtle transient events and gain more profound information about the behaviour of metal stream. Considerable materials are available in literature to understand the influence of gating system design on mould filling using various techniques of direct observation validating the given design of gating system by using real time X-ray radiography to observe the flow of molten metal in a sand mould, or by using contact wire sensing method along with computerized data acquisition, or by using water analogy method to observe the flow of water in a transparent mould.Also few researchers attempted optimization of gating system in casting to control defects and maximize the effective yield of the cast products. This paper comprehensively review the available literature for various techniques to study, analyse and predict the flow behaviour of the melt in order to minimize the related defects arising due to melt flow and also increasing the effective yield of the casting with minimum effect on its quality.

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*Keywords:*Gating Design;Flow Analysis; Numerical Simulation; Water Modelling; Direct Observation; Contact time Method;Optimization Techniques.

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1. Introduction

Casting is the most direct and versatile process of manufacturing in which metal objects is formed by melting and pouring it into moulds. The quality of sand casting predominantly relies on different factors like the melt quality, Methodology for introducing the liquid metal into mould cavity and subsequent metal solidification. The study of filling process is of great significance, for the design of gating system. A well designed gating system should fill the mould quickly, yet quiescently, with minimum turbulence; promote directional solidification; minimize air aspiration thereby reducing re-oxidation and slag formation during mould filling. It should also prevent mould/core erosion and facilitate slag entrapment in the gating system prior to entry of molten metal into the cavity.
Many researchers have tried various techniques which can be broadly classified as computational modelling, physical experimentations (36). Some researchers attempted to use numerical simulation techniques to predict and analyse the molten metal flow characteristics, which has an advantage to accurately predict the subtle transient events and gain more profound information about the flow behaviour (3-11). Also, considerable volumes of materials are available in literature describing an efforts made to understand the influence of gating system design on mould filling either by using direct observation techniques like open mould and through a glass window , by real time X-ray radiography to observe the molten metal flow in a sand mould, by using contact wire sensors along with computerized data acquisition, or by water analogy method to observe the flow of water with tracers or coloured water in a transparent mould. Few researchers attempted optimization of gating system in casting to control defects and maximize the effective yield of the cast products.
This paper attempts to comprehensively review the available literature for various techniques to study, analyse and predict the flow behaviour of the melt, methods advantage and its limitation to analyse the flow characteristics in order to minimize the related defects arising due to melt flow and also increasing the effective yield of the casting with minimum effect on its quality.

2. Literature Survey

Different approaches for study, analysis & visualization of flow through the gating systems are attempted by various researchers through decades which has been presented in their research papers. The purpose of this section is to broadly classify & review the current status of research, pertaining to flow study. The existing literature can be broadly grouped as the methods that deals with: Computer Modeling; Water Modeling; Direct Observation; Contact Wire Sensors methods; and Optimization techniques.

2.1 COMPUTATIONAL MODELING

Early in 1965, Harlov et al. developed a new technique called Marker and Cell (MAC) for numerical investigation of time dependent flow of an incompressible fluid. Navier-Stokes equations were written in finite difference form with a finite time step advancement, while pressure and velocity components were the primary dependent variables. In early eighties (1981) C.W. Hirt developed a concept based on treating complicated free boundary configurations, which was simple yet powerful method called Volume of Fluid (VOF). This method was found to be more efficient and flexible than those existing methods for treating free boundaries. W.S. Hwang and R.A. Stoehr (1983) suggested the suitability of the approaches of fluid flow modeling useful for different purposes. They suggested the Bernoulli's equation approach and Saint Venant Equation approach to be useful for modeling flow of metal through full channels and partially filled channels, like sprue, runners and in gates, respectively. While Marker and Cell (MAC) technique to be useful for plotting the entry of metal with a free surface into the mould cavity. D.H.St.John et al. (1981) adapted a finite element model originally written for flood wave problem for calculating the free surface flow of liquid metals in down runners and gates. Flow patterns predicted by the models were compared with actual flows of metals in sand molds using X-ray technique and with flow of water in clear plastic systems and further refined the model. K.S.Chan et al. (1991) demonstrated a new 3 dimensional technique for handling air-liquid interfaces, as applied to metal casting process. Computations were performed to simulate two distinct filling problems, first dealing with slow filling of a large sand casting mould and other dealing with more rapid situation encountered in