FLUID FLOW PROBLEMS IN HOT MOLDS FOR INVESTMENT CASTINGS OF THIN SECTIONS AND THE DESIGN IMPACT ON METROLOGICAL PROPERTIES

ABSTRACT

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Registration no: 1012112001, Dated: 09/08/2021

Index no.-296/21/E

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2024

Casting quality of metals and alloys depends on both chemical quality of metals as well as physical quality of molds. In modern near net shape technology and thin sections the problems aggravates. Kinetics of liquid metal flow, unlike common fluids, is governed by mechanical functions of fluid flow rule as well as high temperature physical properties of alloys like viscosity and surface tension. Chemical properties of metals are guided by phase diagram and thermodynamic interactions prevailing at high temperature. Common fluid flow rules are compromised by thermodynamics parameters controlled by heat transfer phenomena. Sometime conductive heat transfer dominates the system leaving aside convective and radiative heat transfer.

Over and above mechanical fluid characteristics and the complexities of chemical nature of liquid metal, foundrymen have to encounter unfriendly hot mold behavior with mold-metal interactions which vary quite distinctly over the physical shape of the castings and abrupt change in liquid metal flow in gating system. Even after proper filling of the molds the final physical shape of the casting is guided both by liquid-to-liquid and liquid-to-solid metal contraction which is covered under riser design. Other than thermodynamics behind solidification, physical thermal contraction of pattern shrinkage further complicates the casting shape and size sometimes leading to hot tear and dimensional inaccuracies with high residual stresses. The physical surface imperfections in terms of hills-and-valleys may lead to rejection of casting, particularly in thin sections.

This project makes an attempt to develop an analytical model on theoretical basis for the solution overcoming these physical constraints. During the gating design of investment molds having micron-level thin film filling of liquid metal attempts were made to solve the filling time calculations using this modified Bernoulli's equation.

Hopefully, the new analytical solution of the mathematical problem of investment mold filling time could be taken as a basic or primary solution to solve this kind of problem by software developers, though there is an abundant development of softwares. The obvious reason is quite apparent as all the softwares are basically man-made mathematical tools using numerical techniques, whereas, the rules of physics are guided by Mother Nature and limited in expression.

The modern interventions may be a suitable procedure by means of gating design and riser design, using mechanical and thermodynamic means, followed by sophisticated tooling procedure to improve the acceptability of castings by mechanical engineers. The composite approach of knowledge based design can be very useful to develop quality near net shape castings without compromising mechanical dimensions and metallurgical property with substantial economic advantage and improved productivity.