ABSTRACT
THERMAL DEFORMATION IN HIGH PRESSURE DIE CASTING SHOT SLEEVES

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Replacement of shot sleeves represents a significant cost to cold chamber high pressure die casting (HPDC) processes. It is well known that the service life of a shot sleeve is closely related to its thermomechanical deformation behavior, so an improved understanding of this behavior is needed to guide the design of shot sleeves for increased service life. Prior research efforts have analyzed shot sleeve deformation but were limited to 2D representations and did not consider transient effects from the molten metal’s flow behavior. This study aimed to improve knowledge of deformation during the injection sequence by using a fully 3D multi-physics finite element model which directly simulated fluid flow. To accomplish this, a transient fluid flow model using the volume of fluid method was constructed to simulate fluid flow and heat transfer in the pouring, settling, and slow-shot sequences for four shot sleeve designs, including an eccentric design proposed by this study. Temperature and internal pressure results were exported from this model into a series of steady-state structural models to determine end deflection and total runout along the inside diameter (ID) at five points in time. Deflection results were validated using data obtained from an instrumented shot sleeve during production runs on an industrial HPDC machine. The hottest region of the shot sleeve was directly underneath the pour hole, while the mounting flange used to hold a shot sleeve in place was the coldest. ID size was found to influence deformation more than oil cooling, and most of the shot sleeve’s heat was found to leave through its mounting surfaces, whether oil cooling was present or not. Additionally, the eccentric shot sleeve exhibited the least deformation during the simulated injection cycle. These results indicate that shot sleeve ID size should be minimized in order to extend service life, that the effectiveness of various cooling methods should be reevaluated, and that an eccentric shot sleeve design could provide performance improvement over concentric designs.