

NRC Publications Archive Archives des publications du CNRC

3D Injection Molding Simulation of Semi-Solid Magnesium Alloys Ilinca, Florin; Héту, Jean-Francois; Ajersch, Frank

This publication could be one of several versions: author's original, accepted manuscript or the publisher's version. /
La version de cette publication peut être l'une des suivantes : la version prépublication de l'auteur, la version
acceptée du manuscrit ou la version de l'éditeur.

Publisher's version / Version de l'éditeur:

8th World Congress on Computational Mechanics (WCCM8) [Proceedings], pp. 1-2, 2008

NRC Publications Archive Record / Notice des Archives des publications du CNRC :
<https://nrc-publications.canada.ca/eng/view/object/?id=1417d0ef-c2c0-42cb-a7a9-c0896852cdba>
<https://publications-cnrc.canada.ca/fra/voir/objet/?id=1417d0ef-c2c0-42cb-a7a9-c0896852cdba>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at
<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site
<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at
PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the
first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la
première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez
pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.

IMI 2008-117845-9
CNRC 50244

3D INJECTION MOLDING SIMULATION OF SEMI-SOLID MAGNESIUM ALLOYS

* Florin Ilinca¹, Jean-François Héту² and Frank Ajersch³

¹ National Research Council
75 de Mortagne, Boucherville,
Qc, J4B 6Y4, Canada
florin.ilinca@cnrc-nrc.gc.ca

² National Research Council
75 de Mortagne, Boucherville,
Qc, J4B 6Y4, Canada
jean-francois.hetu@cnrc-
nrc.gc.ca

³ École Polytechnique de Montréal
C.P. 6079, Succ. Centre-ville,
Montréal, Qc, H3C 3A7, Canada
frank.ajersch@polymtl.ca

Key Words: *Semi-solid Metal, Magnesium Alloy, Mold Filling, 3D Modelling, Finite Elements.*

ABSTRACT

Magnesium alloys are increasingly used in automotive, aeronautic and electronic applications to produce high performance, light weight parts. In the thixomolding process the semi-solid slurry is injected into a mold at controlled temperature such that the melt has specific flow behavior. This allows the fabrication of near net shape components with controlled microstructure and good mechanical properties. The numerical modeling of such applications presents unusual challenges for both the physical modeling and the solution algorithm. This paper presents a 3D numerical solution algorithm for the simulation of the injection molding of semi-solid AZ91 magnesium alloys. The methodology deals with the shear thinning, temperature dependent viscosity behavior and is able to accurately solve the high velocity flows encountered during semi-solid magnesium molding. A segregated algorithm is used to solve the Navier-Stokes, energy and front tracking equations [1-3]. The position of the flow front in the mold cavity is computed using a level set approach. Equations are integrated in time using an implicit Euler scheme and solved by stabilized finite element methods. The viscosity is described using a generalized Newtonian model. Two sets of data are used representing the apparent viscosity as measured by two separate experiments.

The approach is applied to the injection of a tensile bar and the results compared with experimental data as shown in Figures 1 and 2. The liquid metal is shown in transparency in Figure 2 such that the void created inside the part to be visible. The numerical solutions indicate that the material forms a jet at the exit of the gate and a swirling flow forms as the material advances along the first larger diameter section. The wall regions are filled first, leaving a void inside. This agrees very well with the experimental observation. The first larger section remains hollow during the filling of the central smaller diameter section. In the simulation using a lower viscosity (shown in Figure 2), the void continues along the center of the smaller diameter section and the material flows along the walls in a spiral motion. This experimentally observed void is not present in the simulation with higher viscosity. Filling of the larger diameter end section, for the lower viscosity case, occurs by the return of the peripheral flow along the central region after it reaches the end of the tensile bar. This agrees again very well with the experimental

observations. The void located in the larger section near the gate is filled last explaining the observed porosity on the molded parts.

The solution algorithm is able to tackle the high Reynolds number, high shear rate flow and to predict jetting, recirculating flow and formation of voids. Both series of computations predict an important zone where porosity is likely to occur agreeing well with experimental observation. The calculated results using the lower viscosity values agree better with the experimental observation. Such a simulation tool could be of great help for mold makers and mold designers. It can assist the prototyping and production phase for optimizing molding conditions.

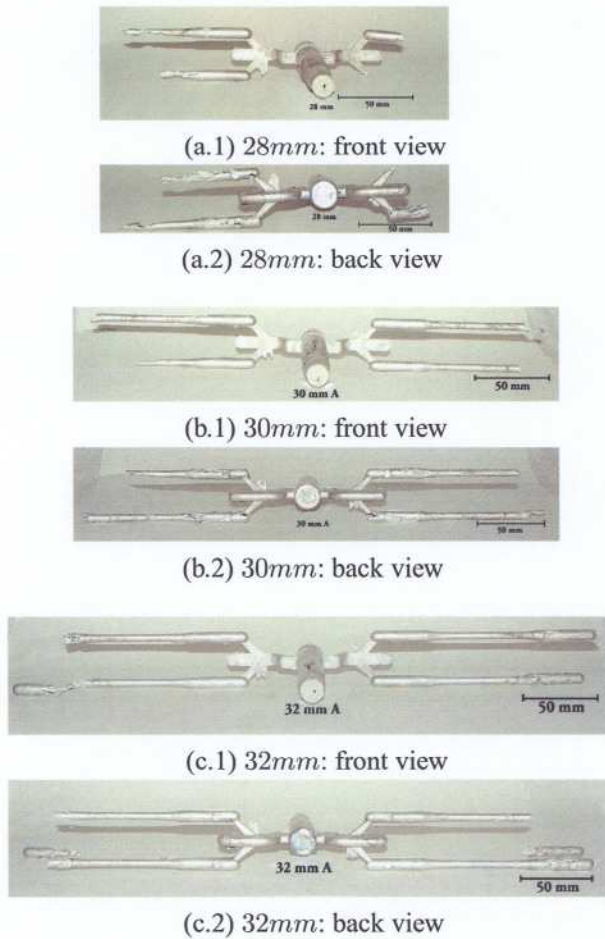


Fig. 1: Experimentally observed filling pattern.

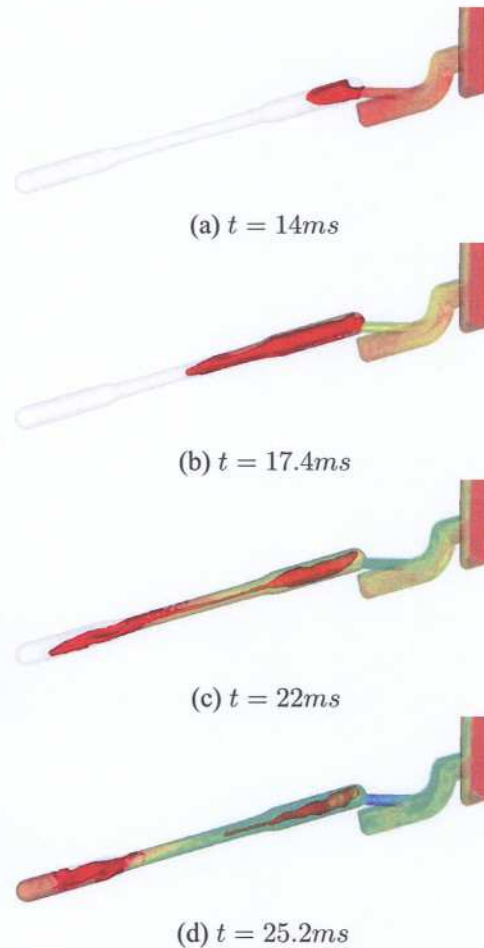


Fig. 2: Computed filling pattern.

REFERENCES

- [1] F. Ilinca, and J.-F. Héту, "Finite element solution of three-dimensional turbulent flows applied to mold-filling problems," *Int. J. Num. Methods Fluids*, Vol. 34, 729–750, 2000.
- [2] F. Ilinca, and J.-F. Héту, "Three-dimensional filling and post-filling simulation of polymer injection molding," *Int. Polym. Proc.*, Vol. 16, 291–301, 2001.
- [3] F. Ilinca, J.-F. Héту, A. Derdouri, and J. Stevenson, "Metal Injection Molding: 3D Modeling of Nonisothermal Filling," *Polymer Engineering and Science*, Vol. 42(4), 760–770, 2002.