A local RBF collocation method applied to two-phase model of viscoplasticity during DC casting of aluminium alloys

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ABSTRACT

Lightness and corrosion resistance of the aluminium lead to widespread use of its use in engineering applications. The aluminium parts in such applications are most often produced by forging from aluminium billets. Quality of the billets thus in large part determines the final properties of the product. The billets used in forging are produced by the process of direct-chill (DC) casting [1]. Knowing the properties of the DC casting process and the conditions, under which the casting defects occur is of great significance to optimization of both, the production yield and the quality of the resulting billet.

To investigate the properties of the DC casting process, a strong-from Radial Basis Functions (RBF)-based meshless method [2], [3] is applied to thermomechanical phenomena which occur during the process. The method uses local colocation with multiquadrics RBF, augmented by linear monomials, to discretize the strong-form equations. The model describes the steady state of the process and is formulated in small-strain approximation. It uses elastic-viscoplastic constitutive model with inhomogeneous material properties. Two-phase constitutive equations including isotropic hardening [4] are used to determine the viscoplastic strain in the mushy zone [5]. The temperature profile, liquid fraction and pressure are calculated by accompanying mass and heat transfer model [6].

In this contribution, the implementation details of the thermomechanical model are presented. The resulting mechanical defects are compared to the results of the single phase model [7], with adjacent discussions on the influence of casting parameters.

REFERENCES

[1] D. G. Eskin, *Physical Metallurgy of Direct Chill Casting of Aluminum Alloys*. Taylor & Francis, 2008.

[2] B. Mavrič and B. Šarler, “Local radial basis function collocation method for linear thermoelasticity in two dimensions,” *Int. J. Numer. Methods Heat Fluid Flow*, vol. 25, no. 6, pp. 1488–1510, 2015.

[3] B. Mavrič and B. Šarler, “Application of the RBF collocation method to transient coupled thermoelasticity,” *Int. J. Numer. Methods Heat Fluid Flow*, (in press).

[4] M. M’Hamdi, A. Mo, and H. G. Fjaer, “TearSim: A two-phase model addressing hot tearing formation during aluminum direct chill casting,” *Metall. Mater. Trans. A*, vol. 37, no. 10, pp. 3069–3083, 2006.

[5] O. Ludwig, J.-M. Drezet, C. L. Martin, and M. Suéry, “Rheological behavior of Al-Cu alloys during solidification constitutive modeling, experimental identification, and numerical study,” *Metall. Mater. Trans. A*, vol. 36, no. 6, pp. 1525–1535, 2005.

[6] V. Hatić, B. Mavrič, N. Košnik, and Božidar Šarler, “Simulation of direct chill casting under the influence of a low-frequency electromagnetic field,” *Appl. Math. Model.*, submitted, 2016.

[7] P. P. Kumar, A. K. Nallathambi, E. Specht, and A. Bertram, “Mechanical Behavior of Mushy Zone in DC casting using a Viscoplastic Material Model,” *Tech. Mech.*, vol. 32, no. 2–5, pp. 342–357, Nov. 2011.