Numerical Study of Horizontal Centrifugal Casting of Rolls

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A numerical model was proposed to simulate casting of an outer shell of a work roll made by the horizontal centrifugal casting (HSC) technique. The present paper is focused on the mathematical description of the average flow dynamics of the liquid metal spreading inside the horizontally rotating mold. Later, we will target on the simulation of the whole casting process (~35 min) which requires an extremely efficient flow algorithm. Therefore, the 2D shallow water equations (SWE) were adopted and modified omitting the momentum in the radial direction and taking into account forces such as the centrifugal force, the Coriolis force, the gravity force, the bed shear force, the shear force due to turbulent effects, the wind shear force, and forces arising from the spatially variable topography. The variable topography will later represent the solidifying liquid/solid interface. An approximate Riemann solver was developed using the standard and corrected Roe averages. Each wave was upwinded using the Godunov's method. The High Resolution corrections (HR) were applied using flux limiters (MC) to keep possible sharp discontinuities in the solution. Transonic waves leading to the expansion shocks were prevented by an extra degree of freedom giving the algorithm a natural entropy fix. All source terms were physically bounded and well-balanced for steady states (producing non-oscillatory solutions). The well-balancing is shown on 1D examples. The effect of forces on the shape of collapsing parabola is shown in 1D in the circumferential direction. Steady state profiles of the liquid height under action of the gravity are discussed for the cases with initially uniform liquid height and a hump in the topography.

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