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Development of a material model for gas generation in inorganic molding materials

Final Report

Motivation

Bonded sand is generally used for lost molds and cores. In view of the increasing importance of environmentally friendly production processes, inorganically bound molding materials are increasingly being used. While toxic exhaust gases are released during the casting process when organic binders are used, casting with inorganic water glass binders largely produces water vapor. Although the inorganic binders are, therefore, significantly more environmentally friendly than their organic counterparts, the two types of binder also differ in the physical principles of gas formation. It is important to know how the gases are released from the molding material over time and how much gas is present in the core at any given time. If the pressure in the core exceeds the counter-pressure of the melt, the gas escapes not only via the core bearings or any vents provided but also through the melt, which leads to porosity in the finished casting.

Procedure

First, inorganic molding materials' characteristics were determined using commercial and self-developed measurement methods. The data obtained was used to develop a model that can be used to estimate the gas impact time without having to explicitly model convection.

Results

The influence of the binder content and the storage conditions on the gas permeability is low. However, the samples with a higher binder content tended to show lower gas permeability. The measurements of water release in the analysis oven developed as part of the project show a similar behavior to the measurements on a commercial moisture balance. The total water content increases exponentially with the relative humidity during storage. The difference between 2.0 and 3.0 weight percent binders also increases with the increase in humidity. When evaluating the time of the gas shock, a smaller delay can be seen with increasing relative humidity during storage. A higher binder content and, thus, a higher water content in the test specimen also tends to reduce the delay time of the gas release.

The data obtained was used to calibrate a model that approximates the movement of moisture inside a molded body using a temperature simulation. If the temperature in the last areas of the molded body rises to the evaporation temperature of the water, the gas shock occurs. The simplified calculation of the water accumulation in the cold areas of the core and the resulting gas shock significantly reduces the calculation time. This makes it possible to integrate the simulation into the design loops and react to critical configurations at an appropriately early stage.

Publications

[1] https://doi.org/10.1007/s40962-023-01090-x
[2] https://doi.org/10.1007/s40962-023-01180-w

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