Conversion of Nuclear Waste Melter Feed to Glass: Mathematical Model of Cold Cap

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The rate of glass production in all-electrical melters greatly impacts the cost and schedule of nuclear waste treatment and immobilization. Mathematical models are thus commonly used today for the simulation of waste melter behavior under different conditions. Regrettably, these models often oversimplify the reaction layer, also known as cold cap, in which the melter feed turns into molten glass. However, without a proper model of the cold cap, it is impossible to reliably predict the melting rate and the melter behavior.

In this study, we report on the development of an advanced model of the cold cap. This model incorporates the dynamic behavior of the foam layer that occurs under the cold cap. The structure and the dynamics of the foam layer are based on the known melting rates of different feeds and their "foaming curves" obtained from feed expansion experiments. Finally, the rate of the feed-to-glass conversion (the rate of melting) is controlled by the heat delivered to the cold cap across the foam layer and from the plenum space.

The advanced model also includes the behavior of solid particles, such as silica and spinel, via sub-models for the mathematical representation of kinetic data from feed-to-melt conversion experiments. In the combination with the advanced cold cap model, these sub-models predict the concentration of undissolved silica and spinel leaving the cold cap into the glass melt circulating in the melter.

The advanced cold cap model is currently being implemented in the model of the whole glass melter. Once incorporated, the combined model will be able to estimate the melting rate as a function of feed properties and melter operating conditions.

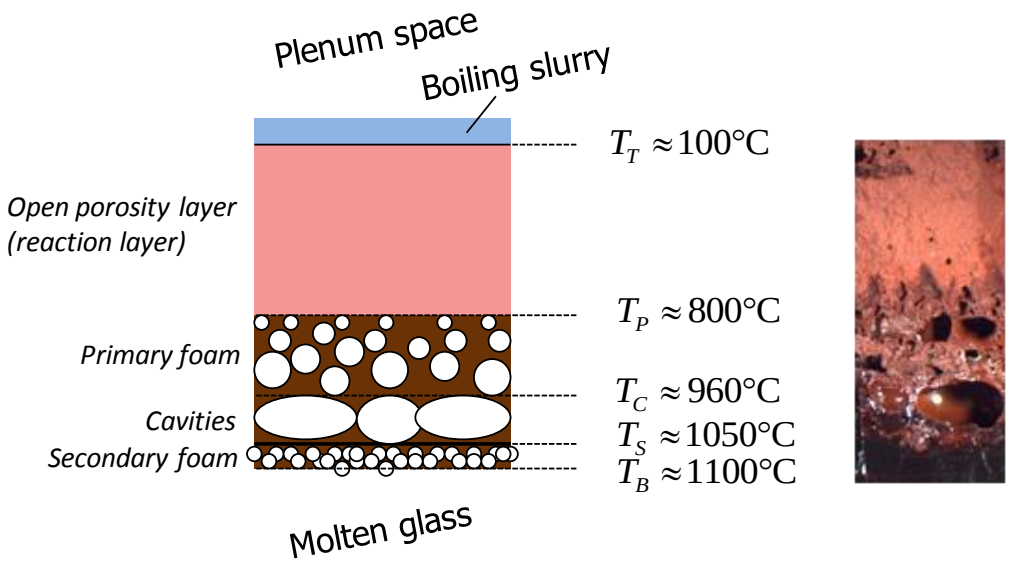


Fig. 1 Schematic illustration of a cold cap (left) and a section through a cold cap produced in a laboratory-scale melter (right).