Building HPC modelling ecosystems for furnace tapping problems

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Our modern industrialised societies are critically dependent on a variety of metals from iron and steel through to technology materials like silicon, copper, and aluminium. The vast majority of these commodities are sourced from metallurgical smelting furnaces of various designs, in which primary or secondary raw materials are converted into the molten state at very high temperatures in order to perform the physical and chemical separation processes necessary for the product of value.

Most smelting furnaces operate in a semi-batch mode, in which raw materials are fed to the furnace continuously but the process products and wastes are removed only at discrete intervals. This removal of the molten materials from the furnace is done using a procedure called tapping – a channel (the tap-hole) is opened in a specialised part of the furnace wall, and the liquid contents are allowed to drain out under the action of gravity and any additional pressure in the vessel. Once sufficient material is drained, the tap-hole is resealed and the process continues. During tapping, human operators and equipment are exposed to molten alloy and slag materials at temperatures in excess of 1500°C. This harsh environment makes any variability or unpredictability in the tapping process potentially hazardous, and at the same time greatly limits the applicability of standard measurement and control instruments. There is therefore considerable value in using computational, numerical, and data-driven modelling tools to provide in silico insight with regard to the design and operation of furnace tapping systems.

This presentation will document Mintek's work over the past few years in developing a diverse software ecosystem for the study of furnace tapping problems, ranging from high-fidelity computational fluid mechanics models through to reduced-order modelling and data-driven machine learning approaches. The common thread of high performance computing as an enabling technology weaves through this story, and is seen to add value in a number of expected and unexpected ways.