BLUE WATERS
SUSTAINED PETASCALE COMPUTING

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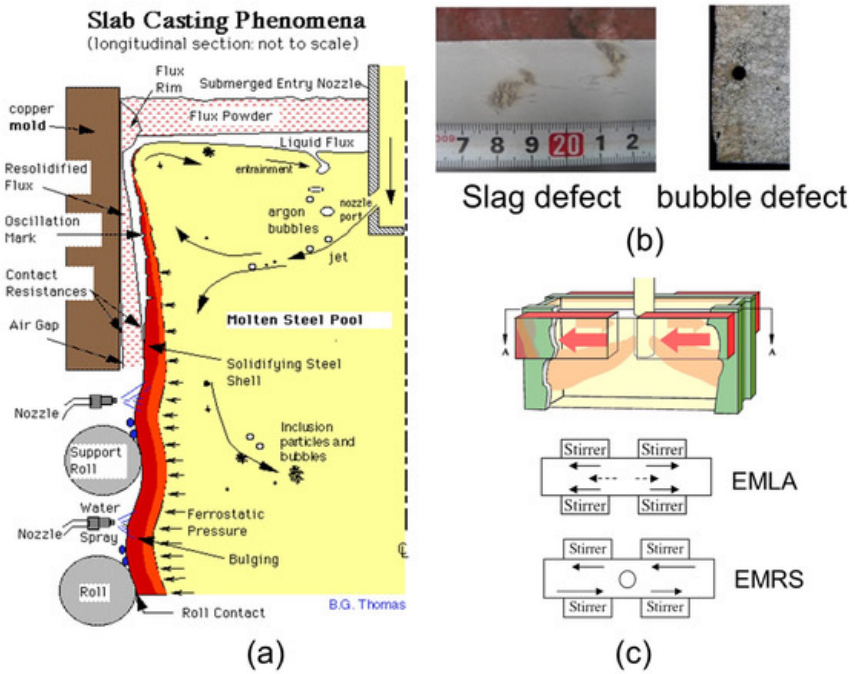
MULTIPHASE TURBULENT FLOW MODELING OF GAS INJECTION INTO MOLTEN METAL TO MINIMIZE SURFACE DEFECTS IN CONTINUOUS-CAST STEEL

Research Challenge

We develop accurate, comprehensive models of multiphysics phenomena in the continuous casting of steel and apply these models to improve understanding of the mechanisms of the formation of defects in the manufacturing process. This work applies transient multiphase flow simulations to quantify argon gas behavior, bubble size distribution, and bubble transport and capture, which influence bubble defect formation. Further we studied the effect of moving magnetic fields on the flow pattern to investigate ways to reduce defects related to entrapped bubbles and inclusions.



Methods & Codes

We conducted these simulations using the commercial CFD program, ANSYS Fluent High-Performance Computing (HPC) on Blue Waters XE nodes. To calculate bubble transport and capture into solidifying steel shells in the mold, we implemented the LES–DPM–MHD model coupled with the advanced force balance (on each bubble at the solidification front) capture criterion model into Blue Waters XK nodes with the multi-GPU based in-house code CUFLOW.

Results & Impact

Our model was able to simulate realistic argon bubble distributions in the molten steel pool in the continuous caster, which enabled more accurate prediction of bubble defects, including their size and location in the steel product, with and without double-ruler EMBr.

Acknowledgements

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Why Blue Waters

Blue Waters enables the simulation of the complex and interrelated transient phenomena on micrometer and millisecond scales in the large volume and long times involved in this large-scale commercial process. We achieved an over three-thousand-times faster calculation with ANSYS FLUENT HPC on Blue Waters XE nodes, compared to an ordinary workstation PC. Furthermore, the multi-GPU in-house CUFLOW codes accomplished a good parallel scalability on Blue Waters XK nodes, showing only 48 hours of wall-clock time for 30 seconds of fully developed LES–MHD flow in a 14-million-cell domain.