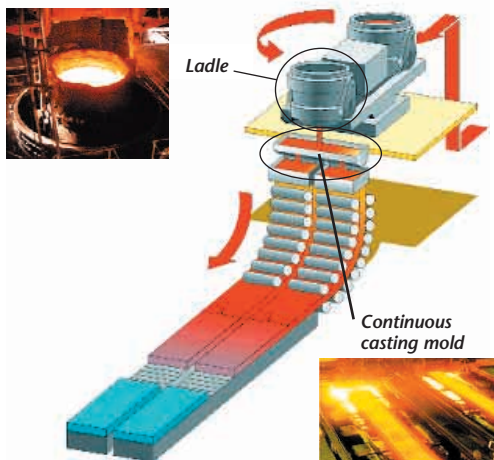


# Steel Industry Applications at ARCELOR

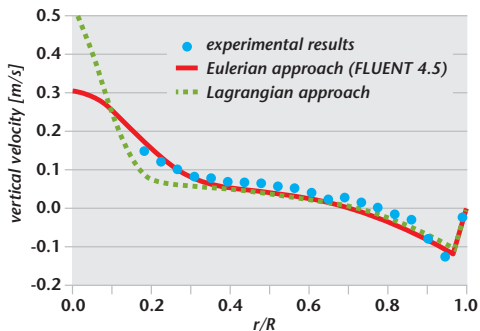
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A vacuum degasser, showing the two snorkels at the bottom



Process chart



Fluid velocity for a water scale model of a ladle – FLUENT results compared to experimental data

The manufacture of steel products is a complex process. Demands for improved product quality have led research centers dedicated to the steel industry to try to better understand all phases of the manufacturing process. Improved measurement techniques and numerical simulation are two of the many areas where the efforts have been directed. At ARCELOR, Europe's largest steel producer and one of the leading steel producers in the world, FLUENT has been used for numerical simulations of various steel production processes, many of which involve multiphase flow. The work has been carried out at IRSID, the company's central research organization.

## purging in a ladle

Steel ladles are used for the transport of molten steel to product forming stations, temporary holding prior to the forming operation, chemical addition, and purging. Chemical addition is done to give the steel the required properties, and purging, usually with jets of argon gas, is done to homogenize the mixture, both thermally and chemically. It is also used to promote the upward motion of inclusions, undesired particulate matter that develops when certain substances are added. A slag, or layer of impurities, forms on top of the molten metal, and by transporting the inclusions to the slag layer, they can be removed with the slag prior to product forming. Both the discrete phase model (DPM) and the Eulerian multiphase model have been used to simulate the purging process, and results are in good agreement with PIV measurements on water scale models.

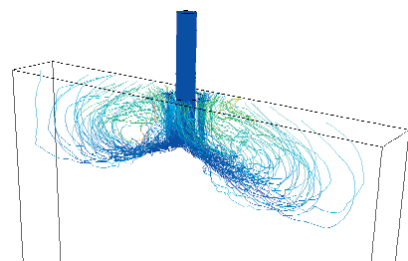
## decarburization in a vacuum degasser

Vacuum degassing is another process that is used to purify molten steel. The steel is drawn up from the ladle through a snorkel into a vessel held at high temperature and low pressure, an environment that helps remove unwanted carbon and dilute gas from the melt. The upward flow is driven by the injection

of argon or oxygen gas. The steel is returned to the ladle through another snorkel after the degassing and decarburization have occurred. FLUENT has been used at ARCELOR to simulate the flow field induced by the gas injections, and to study the tracks of carbon and gas particles in the degasser.

## cleanliness in continuous casting

The continuous casting process has been studied carefully because it is critical to the final product quality. Casting is most successful if there is a gradual yet steady growth of the solidified shell, with few or no inclusions trapped in the material. An understanding of the flow patterns in the casting mold is therefore very important, since it is an indicator of the inclusion behavior and can be used to evaluate the effects of argon injection mechanisms and electromagnetic actuators. The effect of argon injection can be simulated using either the DPM or Eulerian multiphase model. Inclusions, on the other hand, are best modeled using the DPM, since it more conveniently allows for a range of particle sizes and densities. Electromagnetic fields have been incorporated into the FLUENT simulations using a module developed at the EPM-MADYLAM Laboratory in Grenoble. The module includes a Lorentz force term in the momentum equations for the melt and particles that has been found to contribute not only to the flow patterns and particle trajectories, but to the deformation of the free surface as well. ■



Behavior of inclusions injected into a continuous casting mold