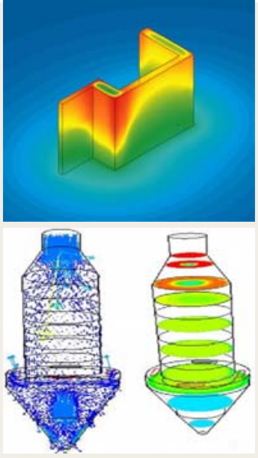


M3TC NUS National University of Singapore

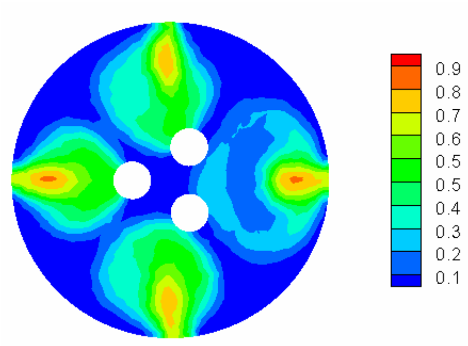
Mathematical Modeling of Mineral, Metal and Material Processing Operations

Principal Investigator: Prof Arun Sadashiv Mujumdar

Minerals, Metals & Materials Technology Centre (M3TC) is the ideal partner for any industry sector seeking to improve its processes through the cost-effective means of mathematical modeling. M3TC's mathematical modeling team is well-equipped with dedicated facilities and expertise to help industry players develop and study simulation models of processes, towards improvement of their processes and products.

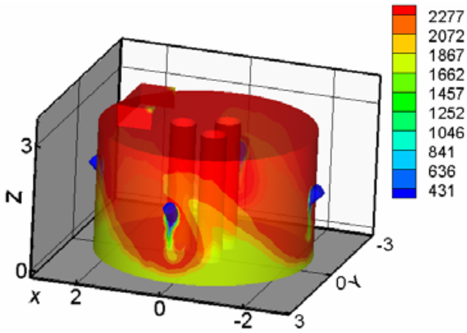
In today's environmentally-conscious climate, process efficiency and energy saving are important aspects to the global mineral, metal and material processing sector. However, advancing process efficiency through experimentation is increasingly resource-intensive in terms of time and finance.

On the other hand, computational resources, both hardware and software, are increasingly powerful and economical. As such, numerical simulation is fast becoming an attractive approach in developing optimal enhancements and innovative alternative pathways to existing process technologies.



Oxygen concentration distribution at the cross-section surface z=0.8 m

Knowledge derived from mathematical modeling may be utilized for the appropriate design of various industrial processes, and for the improvement of product quality. Mathematical modeling, thus, offers the potential for developing innovative techniques in mineral, metal and material processing.



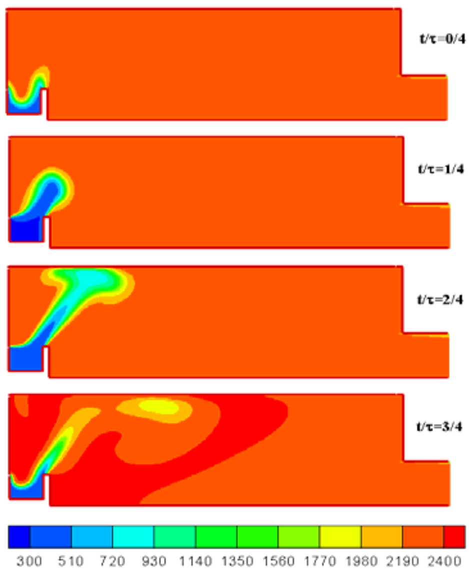
Temperature of post combustion in Electric-Arc furnace.

Our Current Research

M3TC is currently using mathematical modeling to study the various processes in steelmaking and in the making of steel products.

- **Post Combustion in an Electric Arc Furnace**

In the state-of-the-art electric arc furnace (EAF) of a flat-rolled steelmaking plant, approximately1.5 KMol of CO is generated per ton of steel. Combusting this to CO_2 recovers 425 MJ of energy. The potential use of this energy and the corresponding increase in productivity are the economic driving force behind the development of post combustion (PC) technologies. Our 3D computational fluid dynamics (CFD) model for PC provides a valuable tool to examine how and where combustion occurs, and how much and where heat is



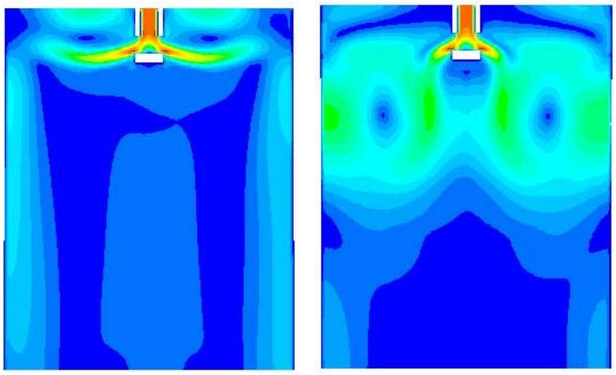
Time sequence of gas temperature contours inside a pulse combustor (K).

- **Pulse Combustion**

The high temperatures and high-velocity pulsating-combustion gas streams generated by pulse combustors instantaneously melt elemental metals and directly convert them into fine metal powder of uniform granule size. Pulse combustion is known for high combustion efficiency and reduced NO_x emission. By mathematically modeling pulse combustion, M3TC facilitates further improvement in the efficiency of the

- **Continuous Steel Casting Process**

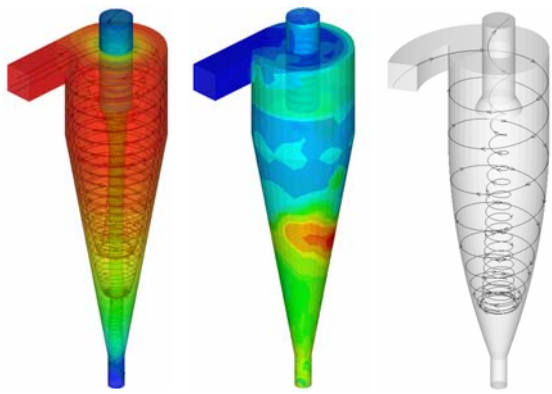
Among the complex phenomena occurring at different stages of steelmaking (eg. tundishes, casting molds, furnaces, etc), our CFD modeling group plans to focus on the effects of magnetohydrodynamics (MHD) on the steel casting process. The aim is to optimize the design of submerged entry nozzles, mold powder performance, electromagnetic stirring (EMS) and design of spray cooling zone, etc.



(a) (b)
Velocity contour for (a) steady case without magnetic field and (b) transient case with magnetic field (MHD model)

- **Design and optimize hydrocyclone**

Hydrocyclones are used widely in many industries. With CFD modeling, the turbulent flow field and erosion rate can be predicted, and how they are influenced by hydrocyclone geometry can be analyzed. The objective is to design and optimize hydrocyclone geometry combining separate efficiency, pumping power requirements and erosion-induced wear.



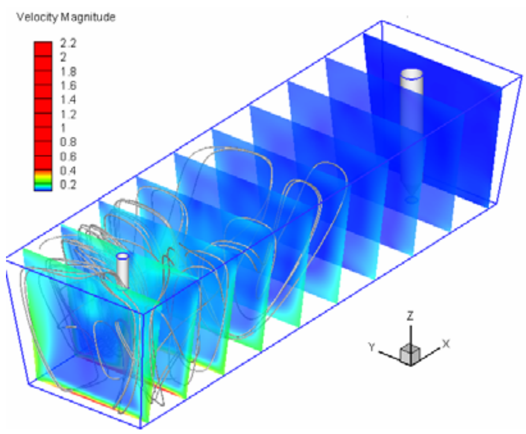
(a) (b) (c)
(a) Streamline, air core and pressure contour in 75mm standard hydrocyclone (b) erosion rate of 75mm standard hydrocyclone (c) One novel design

- **Lost Foam Casting Process**

Lost Foam Casting (LFC) can produce complex-shaped castings in one step without the need for sand binders, which translates into cost-savings and reduced environmental problems. It is important to investigate the mechanisms governing the LFC process, which could lead to the optimization of the casting process for energy-saving and higher product quality; and CFD modeling offers an effective tool for this investigation.

- **Optimization of industrial tundish shape**

Fluid flow phenomena in a real industrial facility were investigated numerically and experimentally using water model to obtain spatial distributions of the velocity vectors, fields of turbulence kinetic energy, temperature of steel flowing in the tundish and the characteristics called RTD (Residence Time Distribution). A novel design of a turbo-stopper is proposed and its function to decelerate the ladle shroud jet and direct the flow back to reduce slag



M3TC has interest in modeling following processes as well. Interested parties are invited to contact us.

- Semi-solid processing of metallic alloys
- Metal spray casting process
- Solidification of metallic matrix composites
- Air entrainment and reoxidation during steel pouring
- Drying of castable refractories

Contact
Professor Arun S. Mujumdar
Director
Minerals, Metals & Materials Technology Centre (M3TC)
Faculty of Engineering, National University of Singapore
Blk EA, #06-15, 9 Engineering Drive 1
Singapore 117576
Tel: (65) 6516 8294 Fax: (65) 6777 6235
Email: mpeasm@nus.edu.sg
Web: http://www.m3tc.sg http://serve.me.nus.edu.sg/arun/