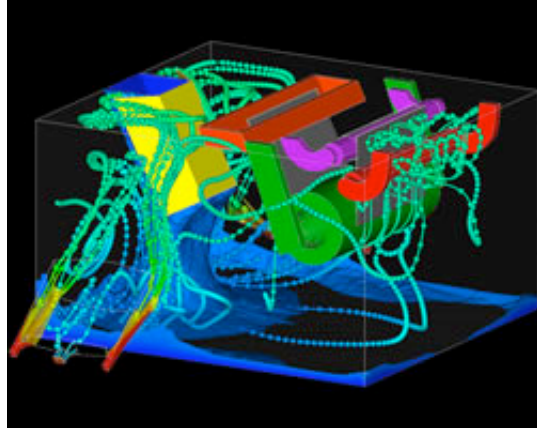


Visualizations, VR Help NRC Canada Improve Steel Galvanizing Process

By Kathleen Wheatley

It supports the tallest skyscrapers and longest bridges. It reinforces automobiles, ships, tanks, trains, and agricultural equipment. Steel essentially composes the world's infrastructure. Although it appears strong and solid, when left unprotected, steel can corrode and rust in almost any environment.

Galvanizing, the process of coating steel to prevent corrosion, has improved its durability and immunity considerably. But National Research Council Canada (NRC) scientists think even more can be done. Sponsored by the International Lead-Zinc Research Organization (ILZRO), researchers at NRC's Industrial Materials Institute (IMI) are using high-end parallel processing computers, advanced visualization software and virtual reality (VR) systems to discover ways to make the industrial galvanizing process better and more efficient.



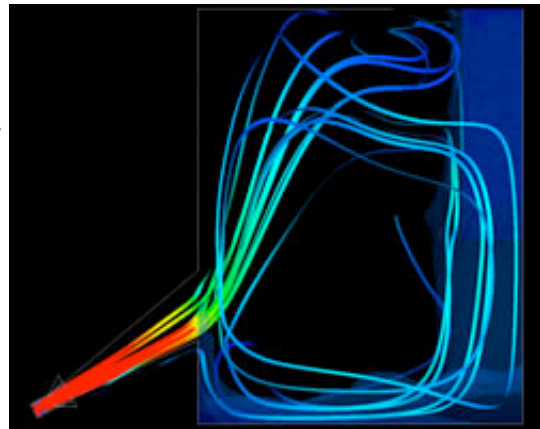
NRC's research is being conducted at the IMI's new virtual processing laboratory in Boucherville, Quebec. The facility houses engineering workstations, a stereoscopic viewing center, and 3D visualization stations with collaborative viewing capabilities. It also boasts a Beowulf cluster, a parallel computing system comprising 128 Intel PCs with Myrinet 2000 interconnection.

IMI has used 3D modeling and simulation technologies to study material processes since 1992. Currently IMI researchers are working with ILZRO and the École Polytechnique de Montréal to better understand typical turbulent flow and heat transfer patterns in industrial galvanizing baths.

Strengthening Steel

Corrosion occurs when the iron within steel combines with oxygen and reverts to one of its many oxide forms. The speed and amount of rust varies with the steel's alloy content, its temperature, the presence of moisture, and other environmental factors. The galvanizing process coats the steel to protect it from oxygen, moisture and corrosive air- and water-borne ions.

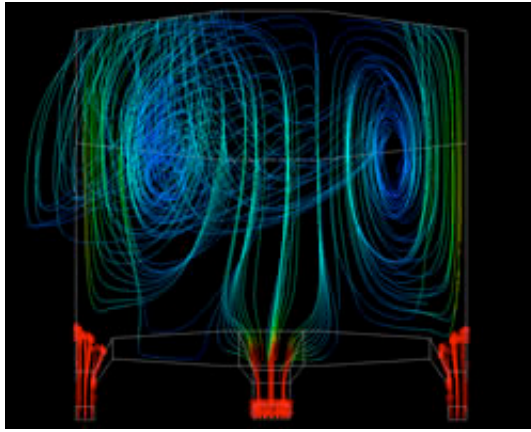
Galvanizing baths, typically used for applications in the automotive and construction industries, cover steel sheets with a coating of zinc and other metallic and non-metallic elements. One of the most common of these added elements is aluminum. Aluminum-rich alloys not only enhance the application of zinc to steel, but also improve certain forming and corrosion-resistance characteristics of the zinc coating.



In the industrial galvanizing process, furnaces known as inductors generate an electromagnetic field, producing enough heat to keep the molten zinc-aluminum bath at coating consistency. Coils of steel are welded end-to-end to form sheets, which are fed continuously through the coating facility at speeds of close to 105 meters per minute. As each sheet exits the coating bath, it is covered with excess molten zinc. The zinc coating can be removed until the sheet reaches the desired thickness. As the steel cools, the zinc solidifies, forming a protective coating on the surface of the metal sheet.

Go With the (Zinc) Flow

The molten zinc-aluminum alloy doesn't move smoothly and evenly in the galvanizing bath. Each steel sheet enters the bath at 1.75 meters per second with inductor power set at 500 kilowatts. The force of the inductors and the movement of the sheet itself create complex flow patterns and eddy currents in the melted zinc coating. IMI researchers are using in-house computational fluid dynamics (CFD) software and EnSight Gold from CEI (Apex, N.C.) to visualize these flow patterns and optimize the galvanizing process.



The first step in evaluating the influence of the turbulent flow is to generate the base configuration of the zinc bath. Researchers create a solid model with Pro/ENGINEER software and import it in ANSYS to create a mesh. Then IMI's in-house CFD software performs flow pattern simulations, which are visualized in EnSight Gold software.

The complex simulations result in datasets of between 450,000 and 1 million tetrahedral elements. These numerical results are essentially huge data files with no meaning if not considered globally, says Alain Malo, a research associate in NRC's process modeling and instrumentation section.

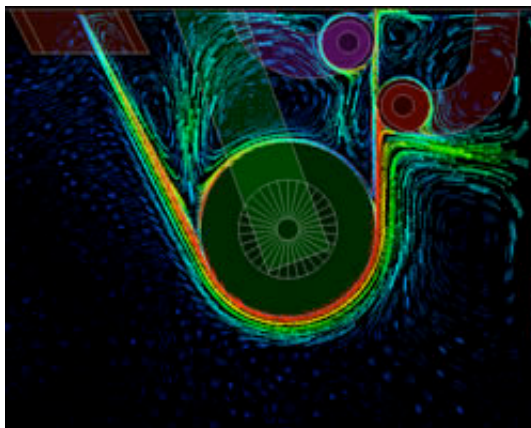
"Our research requires not only an effective tool to visualize large-scale computations, but one that allows us to better understand and interpret our results," he says. "We can animate particle traces, for example, and display movements with the transient flipbook animation in EnSight Gold. These features provide for a more intuitive comprehension of the flow field characteristics."

The Heat is On

IMI scientists are also studying the effects of temperature on the galvanizing process. Heat analysis is of particular importance in the areas of the bath close to the inductor, which generates energy, creating fluid motion and heat. The temperature near the inductor exit is 480° C, while the majority of the bath is maintained at about 464° C. The resulting temperature gradient in the molten zinc causes mixed convection heat transfer.

Mixed convection occurs when both forced and natural convection are present. In a galvanizing bath, forced convection transfer originates from fluid motion created by the inductor. Natural convection transfer is flow driven by buoyancy, which results from density variation as a function of temperature. The higher-temperature zinc near the inductor has a lower density and therefore moves upward. The liquid zinc close to the bath walls is cooler, causing it to flow down to the bottom wall.

IMI scientists are studying how subtle differences in the mixed convection current affect the galvanizing process. They use EnSight visualizations of the streamlines within the galvanizing bath to view temperature conditions for varying simulations that take into account such factors as velocity and pressure. Additional scenarios are created by changing different bath parameters, such as snout depth, roll depth, strip entry angle, and strip width, temperature and velocity.



Researchers use EnSight context files to duplicate the first dataset state for up to eight subsequent datasets.

This speeds up the visualization process considerably, according to Malo, because scientists don't have to spend time recreating parts that had previously been determined in the original dataset.

Bringing Data "Out of the Screen"

After the flow and temperature pattern simulations have been run, the isovolumes, particle traces and transient results are displayed on workstations in the virtual processing laboratory. Here, researchers can visualize multiple datasets by overlapping different meshes, displaying composite solutions of a multi-step process.

In addition to visualizing computational results on traditional workstations, IMI scientists use EnSight Gold on the Fakespace Immersadesk R2 station. Malo says the 3D display provides a highly realistic rendering of objects for the viewer, allowing researchers to more fully understand and substantiate the scientific results.

"Viewing EnSight visualizations on the Immersadesk brings the data out of the screen," he says, "enabling the observer to view the process from any direction. This immersion into the computed data field provides a more intuitive and efficient interaction than would be possible with more conventional visualization techniques."

With each visualization, IMI researchers are learning to better predict flow and temperature patterns in industrial continuous galvanizing baths. This new understanding will allow scientists to improve the effectiveness and efficiency of the galvanizing process. "Ultimately," says Malo, "our goal is to use the state-of-the-art technologies now available to us to produce tangible results for Canada's manufacturing sector and the international scientific community."

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Kathleen Wheatley is a freelance writer specializing in computer graphics and visualization topics.