Cloud-based simulation and education paves the way to future

Prof. B. Ravi

Imagine simulating the solidification temperatures of a casting model that you received as an email attachment on your smart phone (Fig.1). Just upload the model to a cloud-based simulation server, which sends back colour-coded results to your phone within minutes. You can identify hot spots that need to be connected to feeders to prevent shrinkage porosity, or cold spots that may not fill properly and need to be close to ingates. Need to know more about how to design feeding and gating systems, or how to improve the part design for castability? Check out online lesson videos. Want to learn more? Visit the online library, defects museum or projects gallery. This is not science fiction. All these are freely available at E-Foundry, an online portal dedicated to casting design and simulation.

E-Foundry came up in response to three strongly-felt needs. One is the high cost and deep specialisation associated with casting simulation technology that needs to be democratised. Second is the increasing gap between textbooks and industry practice in casting design and simulation, which has to be filled by contemporary knowledge. Third, novel mechanisms are needed to reverse the declining interest and employability of engineering students in manufacturing sector, especially metal casting. These challenges were addressed by setting up a cloud-based E-Foundry, a computer server in IIT Bombay that can be freely accessed by anyone anytime from anywhere through any computing device connected to the Internet. Major facilities include online simulation, classroom, and library.

Fig 1. Casting solidification simulation on the 'Cloud'

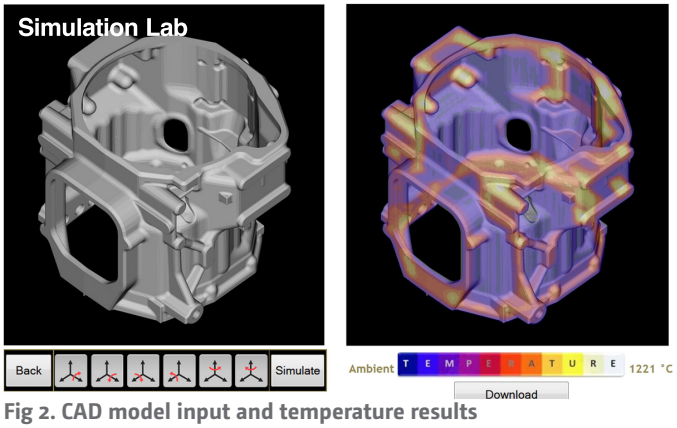

Fig 2. CAD model input and temperature results

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Sim Lab is the heart of E-Foundry. It allows users to upload CAD models of castings; select part metal and mold material; and view colour-coded solidification temperature profile (Fig.2). There is no need to download any program or plug-in. Depending on the model size and connection bandwidth, simulation results are usually obtained within 5-15 minutes. This is achieved by employing a new computational algorithm called Gradient Vector Method. The 3D Modelling Lab provides different ways to obtain the models required for simulation, including a model editor, and a library of several hundred models grouped by shape complexity. An Alloy Database provides the composition and properties of the most widely used ferrous and non-ferrous metals. The Project Gallery displays thousands of castings simulated by users, an interesting and useful learning resource by itself.

Classroom comprises 45 lessons, each with a 10-20 minute video and soft copy of slides. The videos have a well-edited blend of speaker, presentation slides, and audience interaction; their format and size optimized for even smartphones. The lessons are grouped into five sections with learning goals ranging from basic theory to advanced applications. The first section introduces users to casting history, major cast metals and processes. The Science section covers the physics of metal flow and solidification. The Engineering section explains scientific design of cores, mold cavity layout, feeders and gating. The Technology section covers casting simulation, and the Application section shows how to improve quality and reduce costs.

Library provides a range of useful and interesting reference content. Anims & Videos section covers major casting processes, lab experiments, industrial casting, and advanced simulation. Books & Papers section allows users to download selected books, dissertations and technical papers published by the project team, as well as abstracts of several hundred carefully selected relevant technical papers published worldwide. A list of keywords and search facility is available. Defects Museum illustrates blow holes, cold shuts, hot tear, gas porosity, shrinkage and other defects. Sim Cases include examples of quality improvement of industrial castings. Web Links point to research institutes and professional bodies in different countries, along with their short descriptions for easy reference.

Three additional facilities are available in E-Foundry. Tutorial includes design exercises related to core, mold cavity layout, feeder, and gating. Users can select one out of five casting shapes, and one out of five alloys, giving 25 different combinations of answers, which are automatically checked for immediate feedback. Projects

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section contains profiles of active casting researchers, and ideas for relevant research projects. The goal is to encourage students to get in touch with the researchers as well as local industry, and explore collaborative projects. Hub allows members to post questions and answers.

All learning resources can be accessed from E-Foundry home page, which is frequently updated to highlight a lesson, simulation project, case study, a frequently asked question, training programmes and other useful content. Interested users can register and track their progress in terms of the lessons completed, simulations performed, and scores of quizzes and tutorials. ▶

Fig 3. Tabletop casting experiments in E-Foundry Lab

Fig 4. Computer hands-on training for teachers

Since its launch in January 2013, E-Foundry has attracted over 50,000 visitors, each spending 10 minutes on average, and collectively grossing over 300,000 page-views. Nearly 6000 castings have been simulated online so far. Most visitors are from India, USA, Brazil, UK, Pakistan, Germany, Mexico, Italy, Spain, Turkey, China and Australia.

The online learning resources are complemented by a clean and compact E-Foundry Lab (Fig.3). It has a low-cost 3D printer for fabricating plastic patterns directly from CAD models, resin-bonded no-bake molding, tabletop induction melter with direct pouring, and thermal data acquisition system. These have been used for a variety of experiments in molten metal flow, solidification and further cooling, to validate simulation results and develop relevant databases.

To promote the use of E-Foundry resources, 12 teacher training programmes were conducted across India in the last one year, most of them in remote colleges (Fig.4). This has benefitted 550 teachers, who are able to enhance their theory courses, lab experiments, and industry interaction. These institutes have set up or are planning local E-Foundry Cells.

This entire initiative was supported by the National Knowledge Network mission of the Indian Government. It has brought casting simulation technology within the reach of small and medium foundries and engineering colleges, who do not have access to commercial software programs. The integrated learning resources have also empowered teachers to enhance the interest and employability of their students in the manufacturing sector, particularly the foundry industry, which urgently requires a fresh infusion of technical manpower.

Further Reading

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4. Himanshu Khandelwal, B. Ravi and Dipankar, "Tabletop Foundry for Training, Research and Small Enterprises," Indian Foundry Journal, 60(2), 2014, 23-29.
5. M. Sutaria and B. Ravi, "Computation of Casting Solidification Feed-paths using Gradient Vector Method with Various Boundary Conditions," *International Journal of Advanced Manufacturing Technology,* DOI 10.1007/s00170-014-6049-3. ■

More about the author

Dr. B. Ravi is an Institute Chair Professor of Mechanical Engineering at Indian Institute of Technology Bombay, where he joined in 1992 after completing his Masters and PhD at Indian Institute of Science, Bangalore. He is well known for his contributions in casting design and simulation through 220 technical papers, 55 professional training programmes, and over 100 invited talks. His casting simulation technology is benefitting a hundred small and medium foundries, and has been recognized with DST-Lockheed Martin India Innovation Growth Award. Dr. Ravi represented India thrice at World Foundry Congresses, including the recent one at Bilbao, Spain in May 2014, where his paper on E-Foundry was well received and appreciated.

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