CHTE Update

Understanding, Control, and Optimization of the Quenching Process

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About CHTE

The Center for Heat Treating Excellence (CHTE), established in 1999, is an alliance between the industrial sector and university researchers to collaboratively address short-term and long-term needs of the heat treating industry. CHTE is a virtual center with the headquarters at Washburn Shops Worcester Polytechnic Institute; the research work is conducted at WPI as well as the University of Connecticut and the Illinois Institute of Technology. It is the center's intent to enhance the position of the heat treating industry by applying fundamental research to solve problems and to advance heat treatment technology. The research portfolio is member-driven, and the work enhances the industry's technology base, profitability, public image, and education of its members.

Entrance to Washburn shops at Worcester Polytechnic Institute

The quenching research team members are (from left) Juan Chaves, Ma ShuHui, Dr. M. Mani-ruzzaman, and Prof. Richard Sisson, Jr., FASM.

Heat treating is a $20 billion-a-year industry. It is fragmented and research and development necessary for innovation is not carried out across all segments. CHTE provides a critical and important forum where various segments of the industry pool their resources and advance the industry by developing the knowledge base and curricula for education of its future leaders.

Industrial membership includes commercial heat treaters, captive heat treaters, heat treat industry suppliers, and manufacturers of products using heat treating technologies. The center is governed by a board of directors with responsibilities to facilitate, guide, and review research programs.

CHTE has established strong liaisons with the Metal Treating Institute (MTI) and the Heat Treating Society (HTS) of ASM International. CHTE researchers participate at meetings of MTI and the R&D committee of HTS to ensure communication and active dialogue between the association and the professional society serving the industry.

The center pursues research to develop innovative processes to control microstructure and properties of components, reduce energy consumption, reduce process time, reduce production costs, achieve zero distortion, increase furnace efficiency, and achieve zero emissions. CHTE is dedicated to the advancement of heat treating through collaborative research and development in accordance with the Heat Treating Technology Roadmap, the current R&D Plan, and the Vision 2020 document. In this article, we will present an overview of one of the CHTE projects: the understanding, control, and optimization of the quenching process.

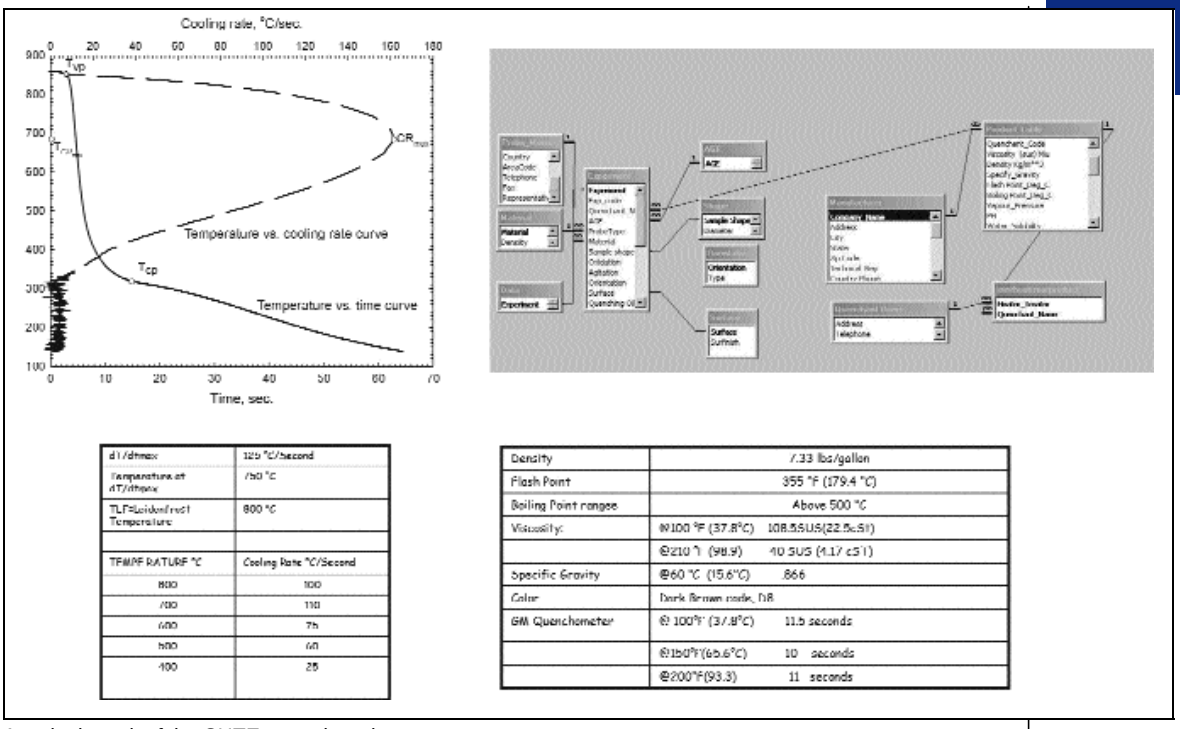
Quenching – Understanding, Controlling, and Optimizing the Process

Each year millions of dollars are lost as a result of distortion, cracking, and mechanical property variations due to unexpected problems in the quenching process. A thorough understanding of the variations in quenching fluid's performance as a function of the medium's physical properties, system variables, and part orientation is not currently available. This understanding would allow the development of improved and controllable quenching fluids and systems, as well as predictive models for the metal's response to the quenching process.

A project in CHTE was initiated in January 2000 to address these issues. The objectives of this project are:

1. Develop a new CHTE quenching media characterization system and probe that will provide heat transfer coefficient data as a function of metal surface temperature, fluid temperature, agitation, metal surface finish, and part orientation.
2. Develop a database for heat transfer coefficients for steels and aluminum alloys in a wide variety of quenching fluids (i.e. water, oils, polymers, salts, and gases) as a function of metal surface temperature, fluid temperature, agitation, metal surface finish, and part orientation. The data for the database will be identified in the literature and taken experimentally using a new CHTE design quenching probe.
3. Develop an understanding of the performance of quenching fluids as a function of the fluid's physical properties (i.e. viscosity, flash point, heat capacity, thermal diffusivity, and boiling point) and part geometry.

The CHTE quench probe system is shown by Juan Chaves.



dT/dtmax	125 °C/second
Temperature at dT/dtmax	750 °C
TLF=Leidenfrost Temperature	800 °C
TEMPERATURE °C	Cooling Rate °C/Second
800	100
700	110
600	75
500	60
400	25

Density	7.33 lbs/gallon
Flash Point	355 °F (179.4 °C)
Boiling Point range	Above 500 °C
Viscosity:	@100 °F (37.8°C) 108.5SUS(22.5cSt)
	@210 °F (98.9) 40 SUS (4.17 cSt)
Specific Gravity	@60 °C (15.6°C) .866
Color	Dark Brown node, D8
GM Quenchometer	@ 100°F (37.8°C) 11.5 seconds
	@150°F(65.6°C) 10 seconds
	@200°F(93.3) 11 seconds

A typical result of the CHTE quench probe system.

4. Benchmark and test the currently available quenching probes.
5. Evaluate the currently available computational fluid dynamics software for their ability to predict the performance of quenching fluids.
6. Develop user friendly software to predict the microstructures of selected steels during quenching as a function of steel composition and quenching fluid performance. The boundary conditions for this software will come from the database developed above.
7. Work closely with Illinois Institute of Technology to provide data that will be needed as the boundary conditions for their models to phase transformations and predict distortion.

To meet these objectives a team of faculty, post doctoral fellows, graduate students, and undergraduate students has been assembled.Professor Richard D. Sisson, Jr., FASM, is the principal investigator, Dr. M. Maniruzzaman is a post doctoral fellow who recently completed his Ph.D. at WPI's Aluminum Casting Research Laboratory on fluid flow issues in metal treatment with Professor M. M. Makhlouf. Ma ShuHui is a graduate student in materials science and engineering at WPI and Juan Chaves is a graduate student in manufacturing engineering at WPI.

Results to date

A new CHTE quenching probe system has been designed, fabricated and tested. The probe can be fabricated from nearly any alloy of interest including steels and aluminum alloys.

The main difference between the CHTE probe and the IVF and Drayton probes is the material of construction for the probe. CHTE is currently using 4140 steel with a variety of surface finishes while the other probes are fabricated from Inconel or another oxidation resistant alloy. The basic difference in design philosophy is that the IVF and similar probes are designed to provide repeatable, accurate characterization of the quenching fluid while the CHTE probe system is designed to provide a characterization of the complete quenching system, including the alloy being quenched, the surface condition of the alloy, and quenching fluids characteristics.

The results from the CHTE probe system can be used to experimentally determine heat transfer coefficients for the steel being quenched that can be used to predict microstructures and distortion.

A database has been designed and is being tested to record and make readily available the important data for each quenching probe system tested. This database includes not only the experimental results from the CHTE or other probe system but also the data that characterizes the quenching fluid. The database for quenching is used for quenching fluid identification, storage of experimental parameters, quenching fluid performance, and quenching fluids experimental parameters.

For more information on CHTE, please contact Professor Diran Apelian at the Metal Processing Institute, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609; e-mail: dapelian@wpi.edu.

Materials Engineering Institute seeks volunteers

The Materials Engineering Institute, the educational arm of ASM International, is seeking volunteers to participate in the product development process by reviewing new concepts. It is also seeking authors and reviewers for product concepts that are in the prototype stage. If you'd like to help develop new courses and training to serve the needs of the industry, please contact Julie Lorence, manager, training product development, Materials Engineering Institute, tel: 440 / 338-5151, ext. 5563; e-mail: jlorence@asminternational.org.

Scholarship application deadline nears

ASM student members are encouraged to apply for the ASM International Foundation scholarships. Visit www.asminternational.org / foundation to get an application. Thirty-seven scholarships will be awarded this year with the value ranging from $500 to full tuition for one year.

- 10 awards at $500 each
- 12 awards at $1,000 each
- 3 awards at $2,000 each
- 10 awards at $6,000 each
- 1 full tuition of up to $10,000
- 1 full tuition

Eligible students must have completed at least one year of undergraduate study, studying materials science and engineering or a related engineering field with an emphasis in materials. All applicants must be members of ASM.

Complete the application forms before the **1 May 2001** deadline. For more information, contact Jeane Deatherage at 440 / 338-5151, ext. 5533; e-mail: jdeather@asminternational.org.