DANTE SOLUTIONS, INC. NEWS MAY, 2022

Spring into action!

We've been hard at work on development for DANTE this quarter. Much like watering the garden and cultivating so the plants can grow, we've been planting the seeds and improving our models so DANTE can grow. Here are some of the many roots that have been developed over the last three months:

- DANTE Solutions is proud to be working with the Cleveland Chapter of ASM International to bring our DANTE software and utility tools to their new Data Ecosystem. The DANTE utilities and software are now available to help users evaluate, design, and optimize heat treatment processes. Several subscription options are available for those looking for short-term DANTE licenses, exclusive to the Data Ecosystem.
- In addition to the DANTE software added to ASM's Data Ecosystem, The DANTE team has developed material and coursework for a class at the ASM International World Headquarters - Materials Park from August 1st through 3rd titled "Analytical Tools for the Steel Heat Treater" The 3-day course offers a fundamental approach to the metallurgy and materials of heat treatment from a design and analysis perspective. The course should be great for anyone looking to learn more about modeling a wide variety of heat treatment processes. We hope to see you there!
- Jason Meyer wrote his first article for Thermal Processing Magazine's Metal Urgency column. The article focuses on fitting valuable heat transfer coefficients (HTC's) from thermocouple data using our HTCFit utility. These HTC's can then be used as thermal boundary conditions in finite element models.
- Justin Sims and Stefan Habean attended an open house meeting for Purdue's Heat Treatment Consortium on May 19th. The School of Materials Engineering at Purdue University is planning to start up a center focused on industry-oriented heat treating projects later this year, and this open house provided a forum for topics and ideas for future projects.
- We continue to improve our precipitation hardening and maraging, aluminum and steel, models with data from papers in the public domain. Presently, the 6061 aluminum model and C64 steel models are being updated with these data. Look for a whitepaper in June for more on the 6061 fitting.

Upcoming Conferences and Meetings

- DANTE submitted a publication for the 4th International Ingot, Casting, Rolling, Forging (ICRF) Conference in Pittsburgh, PA on June 21—23, 2022. The publication, titled "Process Design for Induction Hardening of a Steel Work Roll using Simulation" will also be presented by Justin Sims at the conference. We hope to see you there!
- As a newly selected chair to the Project Selection Committee for the Center for Heat Treating Excellence (CHTE) at Worcester Polytechnic Institute in Worcester, MA, Justin Sims will attend the bi-annual meeting on June 7th and 8th to go over projects and proposals. The meeting is open to all members and guests of CHTE.

Since 1982 we have provided engineering services to the metalworking industries, and for over 30 years we have focused on thermal processing. Our range of services has expanded to include several software products, with our DANTE° software being the premier package in the world for modeling heat treatment of ferrous parts. In recognition of this, we re-branded ourselves as Dante Solutions, Inc. in January, 2014.

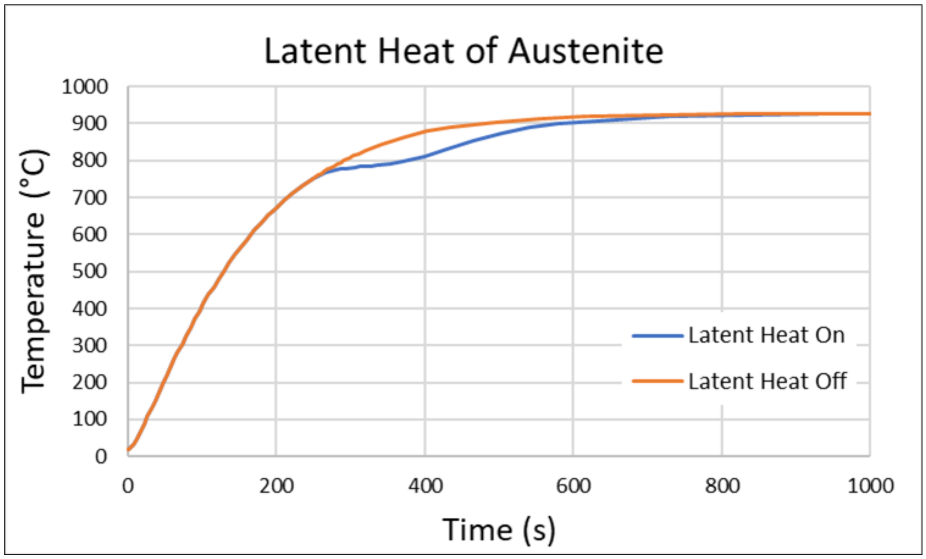
While we use computer analysis tools for most of our work, we are much more than analysts using computer software tools. Our staff includes experts in mechanical and metallurgical engineering. Let us help you improve your heat treatment and deformation processes, use new materials, and develop new products.

Software Highlights

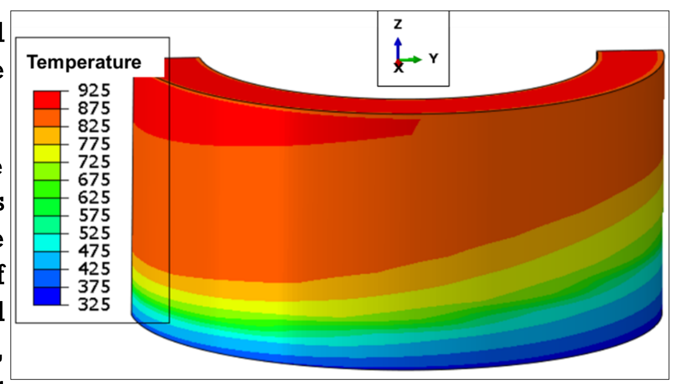
Version 5.1b_pr2 Updates

DANTE Solutions continues to update and improve! New version 5.1b_pr2 adds some exciting features and optimizations including:

- **Latent heat of Austenite during heating**: When Austenite is formed from other phases, heat is required as an input as it is an endothermic transformation. During furnace heating, this is not typically an issue as the parts are soaked for very long times. Latent heat absorbed by austenite can be especially important to high-heating rate and short time period applications like induction and laser heating. This mode can be enabled with the same latent heat flag in previous versions by using a value of 2 to signify latent heat calculations for both heating and cooling.



- ***MAP Solution for Abaqus:** Used to transfer solution variables from a previous analysis to a new mesh that occupies the same space. In previous versions, the field variables would be transferred out of order due to a bug inside Abaqus. DANTE release 'Pr2' ignores the field variables and properly maps the solution variables to simplify transferring heat treatment stresses to updated geometry. A simple loading model is included in the examples folder to aide in formatting this keyword.



- **Directional Convection Variation:** This feature can be used if there is nonuniform cooling (or heating) across the surface of a part in the transverse direction, relative to the quenchant surface. This phenomenon can occur if large parts are racked close together, sharing thermal energy and reducing the cooling on one side of the part, creating a cooling (or heating) gradient. For more on this feature, see the case study on the next page.

- **ACT and Model builder improvements:** The DANTE ACT in Ansys and the Model Builder in Abaqus both include the latent heat of Austenite and directional convection variation features described above for quick and easy model setup.

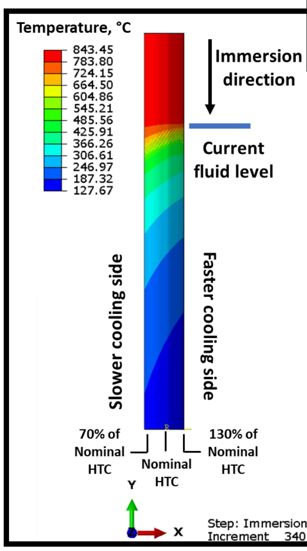
- An improvement to the stress relaxation model to better handle interpolation between defined temperature ranges as also been incorporated into DANTE.

Project Highlights

Directional Convection Variation Effect from Racking

Liquid quenching of long, steel components can introduce significant distortion during the immersion of the component into the quench tank. When placed in close proximity to one another, components may influence the local fluid temperature and behavior, reducing the cooling power locally, when compared to the component surfaces that are facing the quench tank walls. This type of quenching configuration can lead to unexpected and inconsistent distortion results.

The example provided evaluates the response of a long tube that is immersed into the quench bath in close proximity to another tube. The example assumes that the tubes must be lowered into the quench bath with the quench tank agitation turned off to avoid damaging the lowering system. This creates nonuniform cooling conditions during the immersion process as the tubes exchange radiant energy and heat the quench fluid between them. This causes one side of the tube to cool more slowly than the other. Only one tube is modeled, and the exchange of radiant energy is accounted for in an increase in the HTC witnessed by the other surfaces of the tube.



Model Description

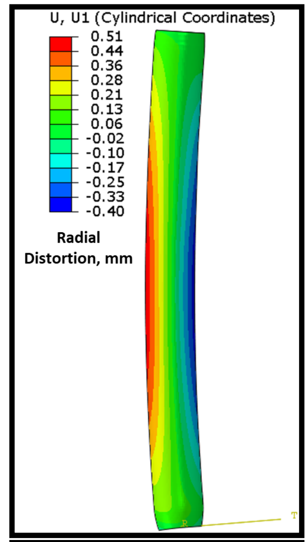
- Material: AISI 9310
- Tube length: 1,000 mm
- Tube diameter: 100 mm
- Wall thickness: 10 mm

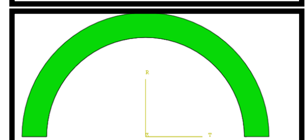
Process Description

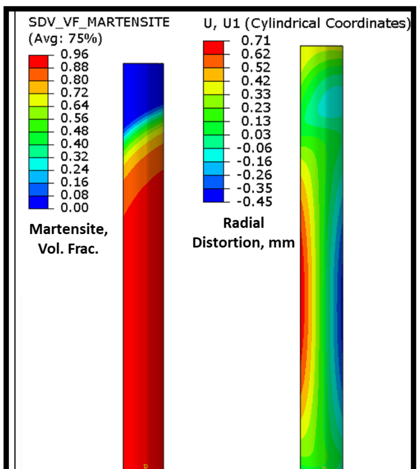
- Austenitization Temperature: 900° C
- Immersion rate: 20 mm/s
- 60% HTC difference on OD at 0° and 180° circumferential position
- Bore is quenched uniformly
- Quench: 15 min, 65° C
- Cool to 20° C after quenching

Results

- Approximately 0.5 mm of bow induced in the tube
- For this material, the martensite transformation is nearly complete prior to the part being fully immersed
- Turning on agitation at this time will not improve the distortional response, as the damage has already been done (below)

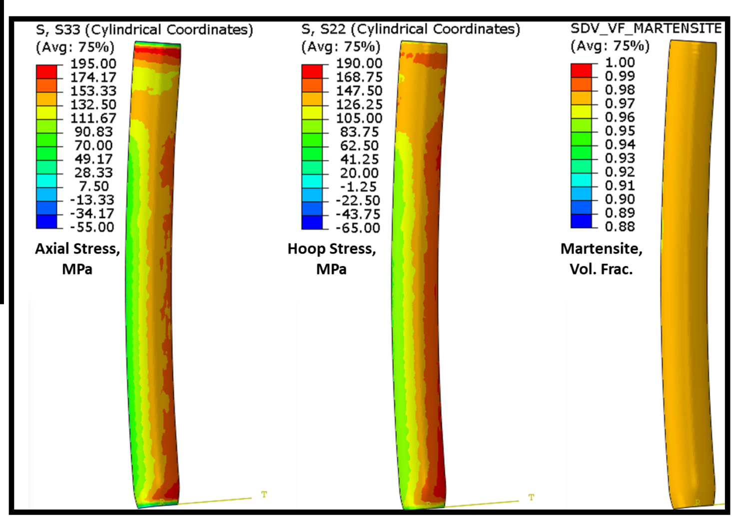



Cylindrical coordinate definition



Condition at end of immersion, prior to starting the agitation

- Nonuniform transformation to martensite creates a nonuniform residual stress state
- Final martensite distribution is uniform
- Stress may create difficulties during straightening or final machining operations
- Model results can be used to determine optimum final machining operations to avoid excessive component movement when stresses are released from material removal



Final Stress and Martensite Distributions