Beating the Summer Heat

Over the past few months we have been developing workshops, coursework and publications to help validate and educate others on heat treatment modeling with DANTE. In the next few months we hope that you will join us for some of these exciting presentations. We continue to work feverously towards the release of DANTE 6.0 early next year. The software highlights and case study for this newsletter come from the development of an aluminum model, with AA6061 being the first alloy in the DANTE aluminum material database; with many more to follow. With the models developed for DANTE 6.0, we move into the testing and documentation phase. Stay tuned for the next newsletter where we show more exciting developments coming to DANTE 6.0.

- Interested in learning more about how DANTE can predict vacuum carburization? We will be conducting a webinar, hosted by ASM, using our VCarb utility tool on Thursday September 8th, from 2:00-3:00pm EDT. The webinar will solve real-world design problems by looking at material selection, part geometry effects, and vacuum carburization process design. Sign up today!

- DANTE Solutions is proud to continue working with the Cleveland Chapter of ASM International to bring our DANTE utility tools to their Data Ecosystem. The DANTE utilities are now available to help users evaluate, design, and optimize heat treatment processes. Several subscription options are available for those looking for short-term licenses, exclusive to the Data Ecosystem.

- The DANTE team has developed material and coursework for a class at the ASM International World Headquarters - Materials Park from October 31st through November 2nd, 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 while earning 2.25 CEU credits. We hope to see you there!

- Justin Sims presented a publication at the 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" was well received. We look forward to future publications at ICRF.

- DANTE Solutions is hiring! We are actively seeking applications for a Mechanical Engineer and a Software Developer with an interest in heat treatment, materials modeling and programming. Send resumes and cover letters to support@dante-solutions.com.

Welcome to the DANTE Family:

- DANTE Solutions would like to warmly welcome Voith Group to the ever expanding list of DANTE users.

Upcoming Conferences

- Come visit us at the International Materials, Applications and Technologies (IMAT) Expo from September 12-15th, 2022 in New Orleans! We are located within the ASM Data Ecosystem pavilion at Booth 438.

- At IMAT, we will be conducting a 4-hour heat treatment course covering general heat treatment from an analytical perspective. Topics include gas and low pressure carburization process modeling and sources of distortion and in-process residual stresses. The course runs from 8am to noon on Thursday, September 15th. We hope to see you there!

- Also at IMAT, DANTE will be participating in the Career Connections program to help students learn more about the opportunities available to them from companies that are actively hiring at the conference. If you are interested in heat treatment, or want to learn more about materials modeling, come have a chat with us!

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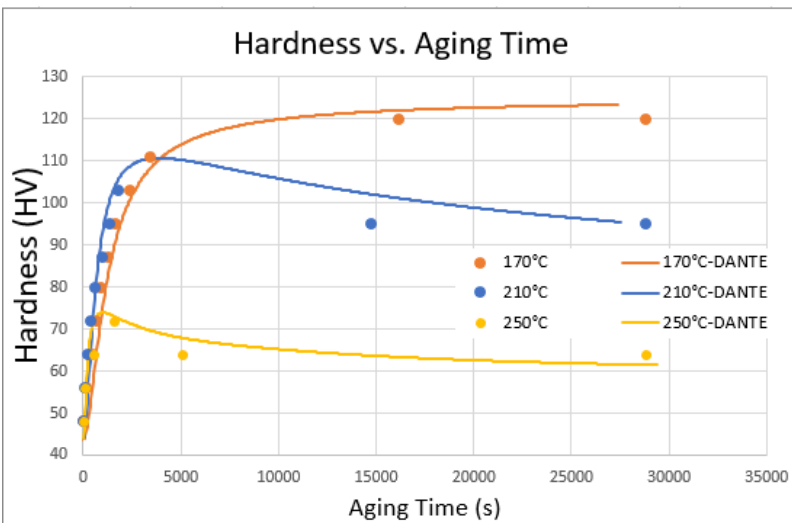
While we use computer analysis tools for most of our work, we are much more than analysts using computer software tools. Our staff includes experts in mechanical and metallurgical engineering. Let us help you improve your heat treatment and deformation processes, use new materials, and develop new products.

Software Highlights

Gearing up for DANTE 6.0

Artificial Aging of Aluminum:

A good materials model for the heat treatment of aluminum must have kinetics that describe the solution treatment, artificial aging, and overaging that occurs throughout the process. The DANTE model uses rate-based equations to describe dissolution of existing precipitates, formation of new precipitates, and precipitate coarsening or overaging. The equations have several adjustable parameters, allowing experimental data to be fit to the DANTE models. Executing experiments can be very costly to obtain these data, setting aside the large time investment. For aluminum alloy 6061 (AA6061), data were collected from publications in the public domain to develop and validate the materials model. The solution treatment parameters were fit based on hardness data after solution treatment for one hour, over a range of temperatures. These data were used as a guide for how complete the solution treatments were based on the achieved hardness after artificial aging.
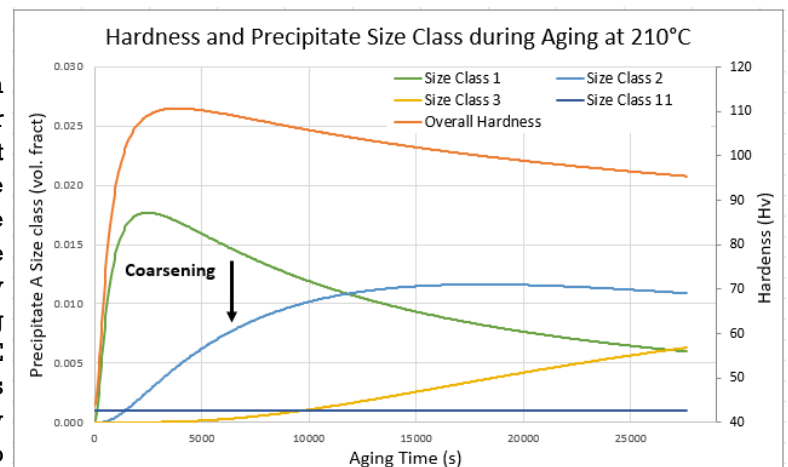

Precipitate Model

The precipitation hardening of AA6061 is governed by the formation of silicon and magnesium precipitates in the aluminum matrix. Temperature has a significant effect on the rate and completeness of the precipitation, and even at room temperature a slow rate of precipitation is observed. For a heat treatment model, where the material experiences a wide range of temperatures, precipitation data collected must include the entire range of processing temperatures. The DANTE precipitation kinetics were fit to hardness data collected for aging temperatures ranging from 150-250°C. This temperature range, though limited, serves as a good baseline for the standard artificial aging temperatures. The data fit was good and shows how significant the processing temperature is on peak hardness during artificial aging.

Coarsening Model:

The plot above illustrates the importance of a coarsening model, given the softening at higher temperatures. At 170°C, the precipitates form without coarsening and reach peak hardness late in the process. At 210°C, peak hardness occurs early in the process and the hardness decreases after reaching the peak. At 250°C, hardness magnitudes are severely reduced as the precipitates coarsen as they are being formed. The coarsening behavior is modeled in DANTE using a size class. Size class 1 represents precipitates without coarsening, and size class 11 represents fully coarsened precipitates. Size class 1 can form, coarsen to size class 2, and 2 can grow to size class 3 and so on, up to size class 11. The plot to the right shows the evolution of this size class during artificial aging at 210°C.

For the sources used in the AA6061 parameter fitting, and more on the process of material model development, see the full white paper on our website.

Project Highlights

Reflecting on the Heat Treatment of Large Telescope Mirrors

Large mirrors made from AA6061 aluminum are often heat-treated and polished for use in space-based telescopes. Despite being difficult to polish, AA6061 is lightweight, dimensionally stable and has good strength after heat treatment, making it a great candidate material for aerospace applications.

SDV_IAL_HARD
(Avg: 75%)
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The heat treatment of these components starts with a solution treatment to ensure a super-saturated solid when quenched. After quenching, the silicon and magnesium solutes begin to precipitate and grow from vacancies in the aluminum matrix. The precipitation rate increases with increased temperature, and most artificial aging occurs between 150°C and 200°C. The heat treatment process, geometry and hardness data selected for this study comes form work performed by Newswander et al. [1]. An axisymmetric model was constructed of the mirror based on dimensions given in the publication. The heat treatment was modeled in Abaqus using DANTE materials models.

Model Description

- Material: AA6061

- Blank Diameter: 569 mm

- Blank Thickness: 160 mm

Process Description

- Solution Treatment Temperature: 530°C

- Solution Treatment Time: 3 hours

- 20% Glycol Polymer Quench

- Artificial Aging Temperature: 180°C

- Artificial Aging Time: 9 hours

Results

- Hardness results, in HV, from the DANTE simulation are shown in the contour below.

- A softer core is predicted after heat treatment due to precipitation during the quench

- - - Surface Path
- - - Centerline Path
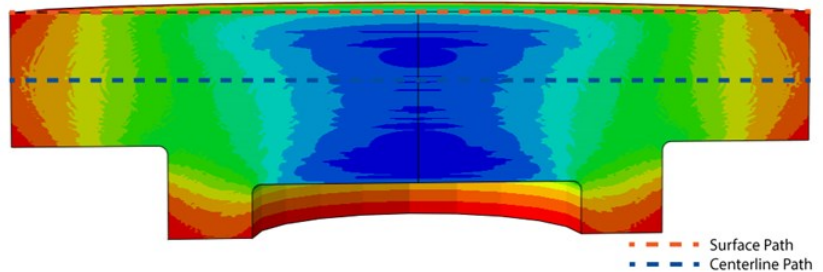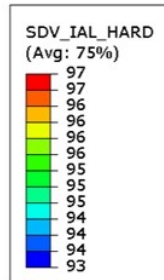
- Hardness traverses were taken along dashed lines in the contour above

- The hardness plot below shows the DANTE simulation agrees well with the published data

Mirror Blank Hardness Traverse
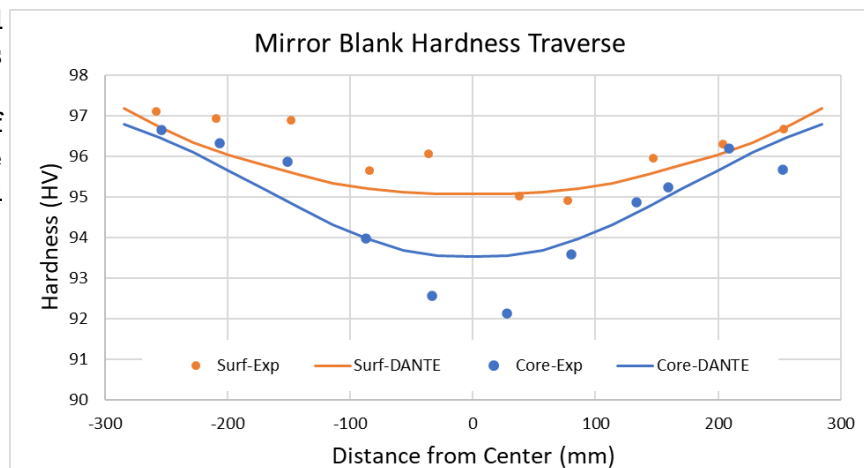
Conclusions

The DANTE aluminum model was successfully used to predict the hardness variation across the diameter of a large reflective mirror. This case study was the last part of a larger effort fit the DANTE aluminum model to public data found for AA6061. If you would like to know more about the process of data fitting, or would like to talk about material model development, contact us.

1) Newswander, T., et al. "Aluminum Alloy AA-6061 and RSA-6061 Heat Treatment for Large Mirror Applications." SPIE Proceedings, 2013

Additional case studies at https://dante-solutions.com/aerospace