Welcome to the DANTE Family!

- DANTE Solutions would like to welcome Sixpro as our newest representative. Located in Brazil, Sixpro provides the heat treatment and metal forming industries with industry specific simulation software licensing, training, and support. They also offer consulting services.

- DANTE Solutions would also like to welcome the following companies from all over the world to our expanding number of DANTE software users:

    - Rolls Royce (USA), Fokker (Netherlands) , SixPro (Brazil), Applied Process (USA), AFC-Holcroft (USA), Toyota (USA)

Quick News:

- Justin Sims will give a virtual presentation at the 2nd International Conference on Quenching and Distortion Engineering. The conference was set to take place in Berlin, Germany, but due to COVID -19 restrictions, will now be held exclusively online on April 27—28, 2021. The publication, titled "Reducing Distortion during Quenching of Steel Components using a Controlled Cooling Method", discusses a novel approach to distortion control for high hardenability steels using a controlled cooling method. The publication discusses the theory behind the process, termed "DANTE Controlled Gas Quenching (DCGQ)", uses simulation to show the improvements of DCGQ over conventional gas quenching, and briefly discusses results from physical testing conducted using a prototype DCGQ unit.

- Justin Sims will also present, hopefully in person, at the 31st Heat Treating Society Conference and Exposition in St. Louis, MO on September 14—16, 2021. The publication, titled "Process to Minimize Distortion during High Pressure Gas Quenching Processes", examines the DCGQ prototype unit, operation, and experimental results in more detail than that provided in the "Reducing Distortion during Quenching of Steel Components using a Controlled Cooling Method" publication.

- Jason Meyer will also present at the 31st Heat Treating Society Conference and Exposition. His publication, titled "Modeling the Effect of Chemistry Changes on Phase Transformation Timing, Hardness, and Distortion in Carburized 8620 Gear Steel", will use simulation to explore the effects of alloy composition variation on the heat treatment response of AISI 8620 steel alloy. The publication also validates the DANTE model against published data for AISI 8620.

- Charlie Li will also participate in the 31st Heat Treating Society Conference and Exposition by advising a group of Cleveland State University engineering students competing in the ASM Heat Treating Society Strong Bar Student Competition. The competition challenges students to develop an optimum heat treating recipe for AISI 4140 with respect to bending strength.

- DANTE Solutions is pleased to continue supporting ASM International activities by serving on two newly established technical committees:

  - Materials and Processes Modeling, chaired by JP Thomas of Pratt & Whitney: The Materials and Processes Modeling Committee will look at all aspects of materials processing from raw materials to parts in service, so naturally thermal processes and heat treatment will be important to committee activities.

  - Residual Stress, chaired by David Furrer of Pratt & Whitney: Likewise, heat treatment and thermal processes will be an important part of Residual Stress Committee activities where residual stress can be problematic in terms of distortion during part manufacturing and either beneficial (surface compressive stress) or detrimental (surface tensile stress) during part service.
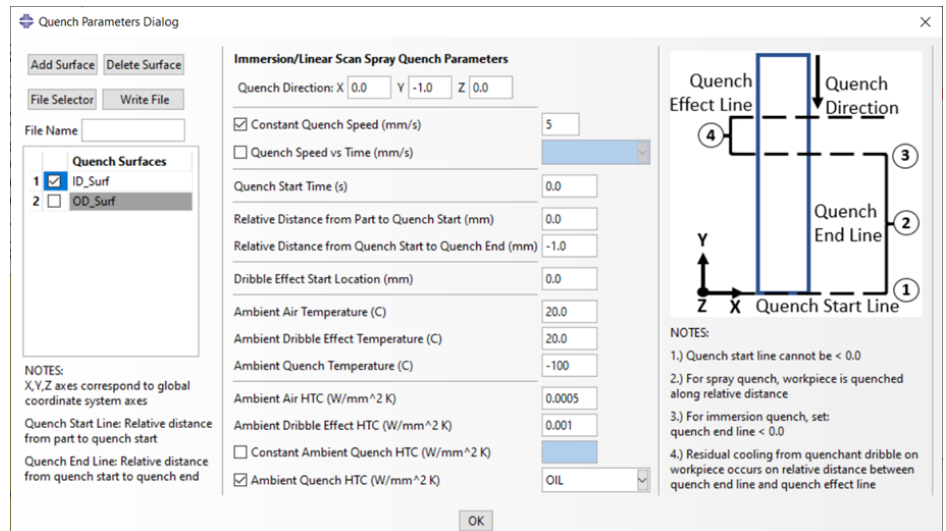
Software Highlights

IMMERSION QUENCH PLUG-IN CAPABILITY

DANTE Solutions, Inc. is excited to announce the introduction of our immersion quenching capability to the DANTE Plug-In for Abaqus. With the ability to easily enter the required parameters, quenching simulations of long components is now easier than ever!

Lowering a long component into a quench tank results in nonuniform cooling in the axial direction of the component, influencing the transformation timing and resulting distortion. DANTE includes the capability to model this process, but until now, required an external file to be manipulated by the user. The Plug-In now handles the file creation and applies the correct Abaqus keyword definition from values provided by the user. The DANTE Immersion Quenching subroutine comes with the following features:

- The direction of the quench can be in any spatial plane, with respect to the 3D global coordinate system in the model, allowing for quick evaluation of multiple quench angles.

- The quench rate can be constant or a function of time.

- Multiple surfaces can be defined independently, allowing for the filling of blind holes or angular tube sections to be accurately described.

- The subroutine can also be used to simulate a linear scanning spray quenching operation.

- The subroutine calculates the point of liquid/air interface and applies the appropriate heat transfer coefficient and ambient temperature. The effects of splashing, overspray, or spray dribble can also be considered.

- Ambient temperatures for the air around locations of the part not being quenched, the quenchant, and the splash/dribble zone are each defined separately and are assumed to remain constant.

- Heat transfer coefficients for the air and the splash/dribble zone are each defined separately and are assumed to remain constant.

- The heat transfer coefficient for the quenchant is defined separately and can be defined as a constant or as a function of part surface temperature

- Rotational spray quenching can also be modeled, though a different table is provided

Project Highlights

Scanning Induction Hardening of a Truck Axle

Objective:

- In this study, a full-float truck axle, manufactured by Dana Corporation, is chosen as a typical shaft undergoing an induction hardening process. The DANTE software is used to explore the effects of quench rate and material selection on residual stress.

Geometry & Model Description:

- Material: AISI 1541

- 1 m long

- 35 mm shaft diameter

1008mm
CAD Model
R=9.52mm

- Model uses a single-tooth sector of the entire shaft

FEA Model with fine surface mesh.

- Assumes each tooth behaves the same

- Induction heating process modeled by Fluxtrol using Flux 2D

- Joule heating as a function of position and time from Flux 2D model used to drive DANTE model
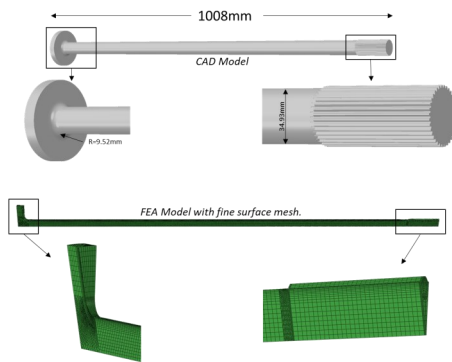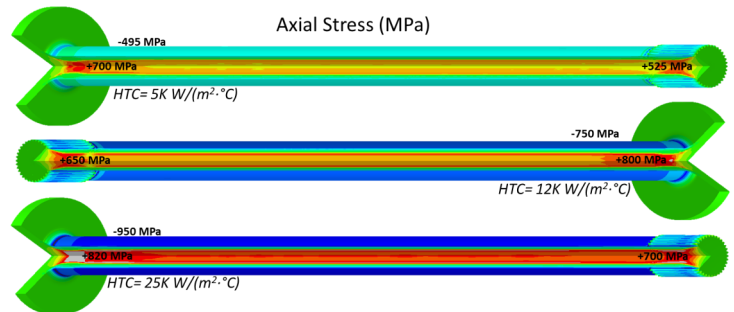
Results: Varying the Quench Rate

- Three quench rate heat transfer coefficients were evaluated: 5, 12, and 25 kW/(m^{2}K)

- Significant differences in stress magnitude exist

- The higher the quench rate, the higher the surface compressive stresses

- The higher the quench rate, the higher the subsurface tensile stresses

- The high quench rate provides benefits to handling a bending load, but may cause centerline cracking if loaded in tension
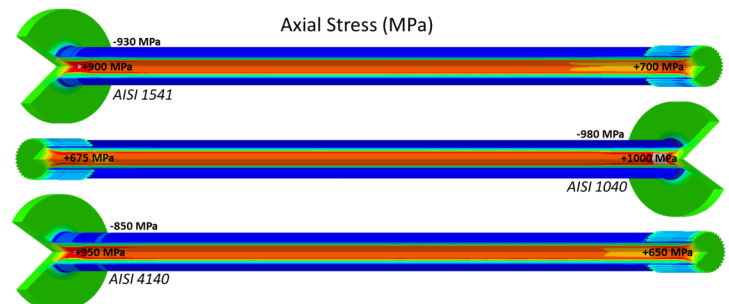
Results: Varying the Quench Rate (cont'd)

- Axial stress is shown below; hoop stress follows a similar trend, though the subsurface tension is significantly reduced

- Reducing the quench rate from 25 to 5 kW/(m^{2}K) reduced the axial tension from 820 to 700 MPa

Axial Stress (MPa)
-495 MPa
+700 MPa   +525 MPa
HTC= 5K W/(m^2·°C)

-750 MPa
+650 MPa   +800 MPa
HTC= 12K W/(m^2·°C)

-950 MPa
+820 MPa   +700 MPa
HTC= 25K W/(m^2·°C)

Results: Varying the Material

- Three different materials were evaluated using a quench rate of 25 kW/(m^{2}K): AISI 1541, AISI 1040, and AISI 4140

- AISI 1541 and AISI 4140 show similar residual axial stress magnitudes, as shown below

- AISI 1040 has slightly increased residual axial stress magnitudes due to its reduced hardenability and variation in transformation timing compared to AISI 1541 and 4140

Axial Stress (MPa)
-930 MPa
+900 MPa   +700 MPa
AISI 1541

-980 MPa
+675 MPa   +1000 MPa
AISI 1040

-850 MPa
+950 MPa   +650 MPa
AISI 4140

Conclusion

- DANTE was used to successfully evaluate various quench rates and material choices on residual stress

- Although a faster quench rate will yield the most favorable residual stress for bending, it may result in centerline cracking if loaded in tension

- DANTE can be used to determine optimum processing parameters and material selection given a particular loading condition

One can view this, and many more automotive case studies online at: **https://dante-solutions.com/automotive**