

New Beginnings—Springing into Summer

The new year brings new beginnings for DANTE with more office space, motivated engineers, and improved models. To kick off this newsletter, DANTE Solutions welcomes the newest members to the team:

Vinayak Mathur (aka Vini; Software Engineer): Vini is a Software Developer and graduate of Case Western Reserve University in December of 2022 with a Bachelor's in Computer Science.

He has previously worked as a Software Engineer and Portfolio Manager at a startup hedge fund based out of New York and as the Director of Design for the CWRU student newspaper, "The Observer".

Vini is applying his experience in the software development life cycle and graphic design to the DANTE HTSuite. His technical interests include full stack web development, desktop application development, performance optimization and all things GNU/Linux.

Vini is an avid audiophile and part-time singer songwriter. He also likes to spend his time playing soccer and engaging in competitive coding.

Jay Grzep (Intern): Jay is a full-time student studying Mechanical Engineering at Cleveland State University. He transferred to CSU after receiving an Associates of Science and Associates of Arts from Cuyahoga Community College as part of the Mandel Scholars Academy.

He is an intern at Dante Solutions starting January 2023 and is learning to apply classwork knowledge to simulating real-life metalworking processes using the DANTE plug-in with Abaqus and Ansys.

In his free time, he works part time at the Great Lakes Science Center and enjoys attending local events with his friends.

Quick News:

- We have officially released DANTE 6.0! With precipitation models to handle aluminum, nickel-based alloys, and secondary-hardening steels and many more new features, DANTE 6.0 is the next step in heat treatment simulation evolution. Contact a DANTE engineer to request your copy today!
- DANTE Solutions moved to a new office space at the end of 2022. Still conveniently located near downtown Cleveland and Hopkins International Airport, the doubling of floor space will allow DANTE Solutions' expansion to continue as more engineers join the DANTE team.
- DANTE Solutions will be teaching an ASM International Course, titled "[Analytical Tools for the Steel Heat Treater](#)" on May 8—10 2023. Come join us at Material Park for this one of a kind class and earn 2.25 Continuing Education Units (CEU). DANTE engineers will share their breadth of modeling knowledge, as well as provide hands-on examples using DANTE's suite of heat treatment simulation tools.

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

Virtual Gear Measurements!

DANTE Solutions and Alfonso Fuentes Aznar (Rochester Institute of Technology) have joined forces to introduce virtual inspection of simulated heat treated gears.

Integrated Gear Design (IGD)

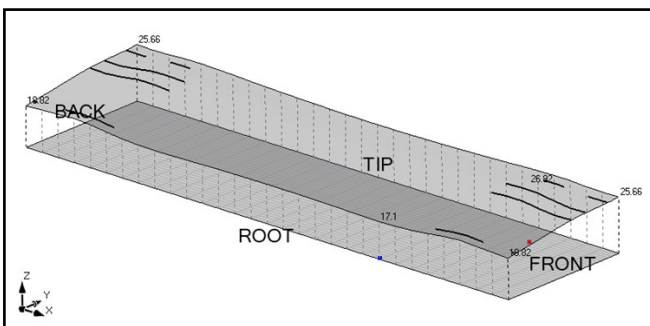
IDG was developed by Alfonso to aid in constructing gear geometry from gear parameters (number of teeth, module, pressure angle, etc.), including generating the mesh for finite element analysis. The model created with IGD can then be used to simulate loading conditions in Abaqus. The results can be read back into IGD to perform post-processing operations and it is able to report measurements in the forms commonly used to make gear measurements on the shop floor. IGD can now read in the distortion results from a DANTE heat treatment simulation!

Example of IGD inputs

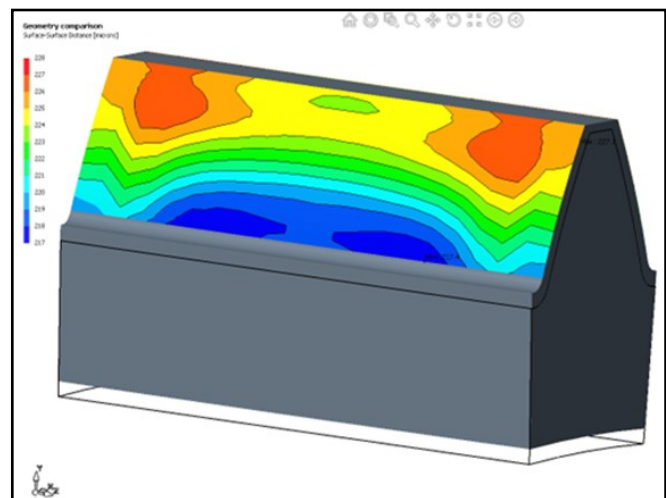
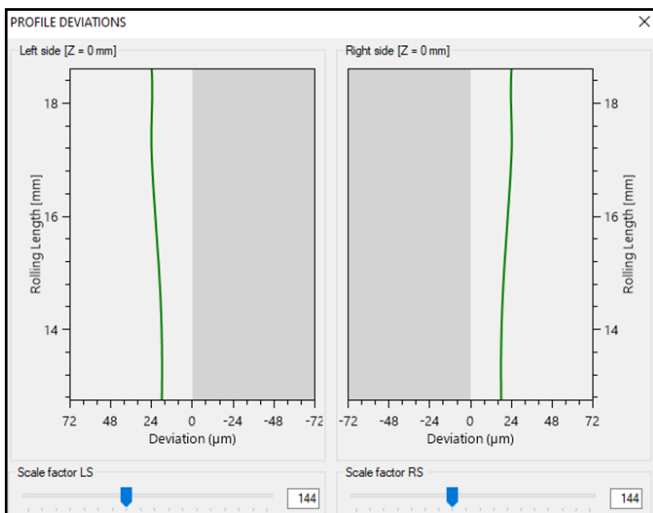
Parameter	Heat-treatment geometry	Finished geometry
Number of teeth	59	
Module	1.25 mm	
Pressure angle	25°	
Face width	9.6 mm	
Tip diameter	76.40 mm	76.20 mm
Root diameter	71.025 mm	70.60 mm
Edge radius of hob	0.12 mm	0.312 mm
Pin diameter	2.3 mm	
Distance over pins	77.885	77.010 mm

Post-processing Capabilities

Comparing geometries is an important feature of IGD and can be directly applied to compare distortions of the heat-treated geometry with respect to the green or finished geometries. In the bottom-right figure, it can be seen that uniformly machining or grinding the gear to the final dimensions (wire frame) will not work. Due to the relatively uniform carbon depth, any nonuniform material removal will result in a nonuniform hardness and residual stress distribution that may influence the gear's in-service performance, which can then be evaluated through additional analyses; including rebalancing of residual stresses, new hardness profiles, and subsequent mating and loading behavior after final machining.



IGD also provides several features to quickly analyze tooth profiles (2 bottom-left figures), which is crucial to ensuring that mating gears will perform as intended. The top figure evaluates the entire flank profile on one side of the tooth, while the bottom figure evaluates the flank profile of both sides through a transverse cut. Additional post-processing capabilities, including the distance over pins and runout for the distorted geometry, are being developed at this time.



Project Highlights

Importance of Modeling Carbide Formation during LPC

Low pressure carburizing (LPC) has many benefits over atmospheric (gas) carburizing. However, steel alloys containing strong carbide formers must be given extra care when developing a recipe. Due to the saturation of carbon in austenite, carbides easily form if given even a small amount of certain alloys; namely Cr, Mo, V, and W. Since it is impossible to tell with certainty whether carbides formed during the process, and then simply dissolved during the final diffuse step, simulation that can model the formation and dissociation of carbides becomes an invaluable tool when designing LPC recipes for steel alloys with strong carbide forming elements.

The following study showcases the importance of modeling such phenomenon. The DANTE utility, VCarb, is used to simulate the LPC process described in "[The Effect of the Quenching Method on the Deformations Size of Gear Wheels after Vacuum Carburizing](#)" by Konrad Dybowski. The simulation results are then compared to measured values and the importance of a carbide model is demonstrated.

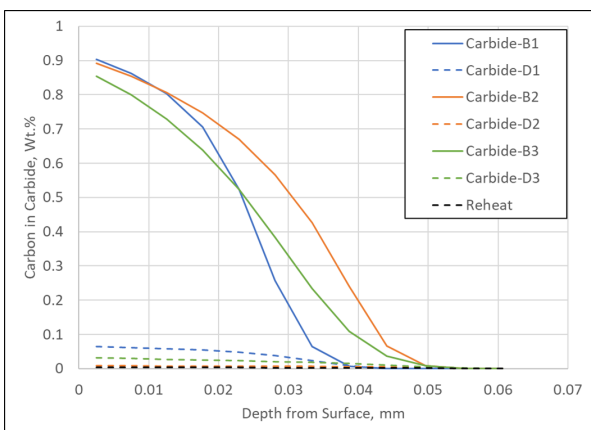
Process Description

LPC Process (Boost/Diffuse pairs):

- 6 min/13 min; 4 min/34.5 min; 3.5 min/16 min

Reheating Process (further carbon diffusion):

- Heat to 950° C with rate of 10° C/min
- Reduce to 860° C and hold for 20 min



Carbide formation and dissociation during process

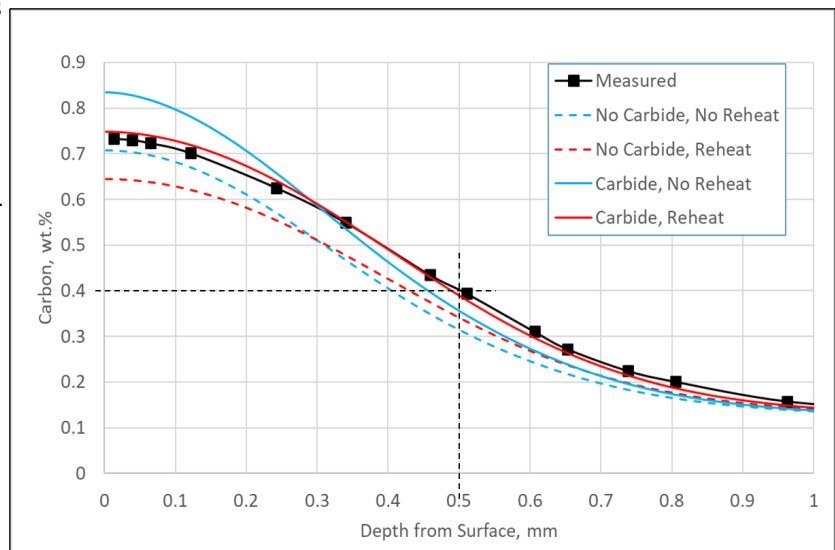
Modeling Approach:

DANTE VCarb used to simulate 4 cases:

- No carbides and no reheat
- No carbides and reheat
- Carbides and no reheat
- Carbides and reheat

Results

- Without modeling the carbides or reheat, the surface carbon is close to the measured value, but the case depth is underpredicted by 0.1 mm
- Without modeling the carbides, but including the reheat, the case depth is underpredicted by 0.5 mm and the surface carbon is underpredicted by 0.1%.
- With carbides and no reheat, the case depth is only underpredicted by 0.25 mm, but the surface carbon is overpredicted by 0.1%.
- Including the carbide formation/dissolution and the reheat, the prediction matches the measured values exactly. Carbides form during boost steps (B1, B2, B3) and dissolve during the diffuse steps (D1, D2, D3).



Final carbon profile for 4 VCarb cases and measurements

Conclusions

- Simulation can be a powerful tool for the design of LPC recipes for steel alloys with strong carbide forming elements, but only if the model includes carbide formation and dissolution.
- The importance of modeling reheating steps in determining the final carbon profile is critical.