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Got Residual Stress

ASM INTERNATIONAL RESIDUAL STRESS TECHNICAL COMMITTEE

A parlor trick or the precursor for safety glass?

WRITTEN BY LESLEY FRAME

In the 17th century, German Prince Rupert of the Rhine brought glass drops to England's King Charles II as an intriguing parlor trick. The elegant tear-drop shaped glasses include a very long "tail", but what makes them so impressive is their extreme surface compressive residual stresses. The high magnitude negative stress increases the surface strength of the glass drops such that one can actually hit the drop with a hammer and it will not break. However, as soon as you snip the tip of the tail, the stresses are released, and the entire drop shatters into thousands of tiny pieces. The compressive residual stresses form when a molten drop of glass is quickly cooled in water. The rapid solidification at the surface locks in a large volume amorphous structure and the interior forms a slightly smaller volume structure. The volume differences ensure that the surface is in compression and the center of the drop is in tension. Check out this video created by Purdue Engineering to learn more about these drops:

https://youtu.be/lt-zvsGvtqg.

As it turns out, we still use the principle of controlling residual stress through thermal processing of glass today. So-called safety tempered glass is heat treated to ensure that surface compressive stresses are high enough in magnitude that when the glass breaks, it breaks into pea-sized pieces rather than large sharp shards.

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FIGURE : TEST RING SAMPLES FROM VARIED MANUFACTURING STEP.

Changes in Residual Stress State During Quench and Temper of Vacuum Carburized Gear Steel

Vacuum carburizing of 9310 gear steel followed by austenitizing, oil quench, cryogenic treatment, and tempering is known to impact residual stress state of the steel. Residual stress magnitude and depth distribution can have adverse effects on part distortion during intermediary and finish machining steps. The present research provides residual stress measurement, microstructural, and mechanical property data for samples taken along a specific heat treat sequence.

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Test rings of AISI 9310 steel are subjected to a representative gear manufacturing sequence that includes normalizing, rough machining, vacuum carburizing to 0.03", austenitizing, quench, cryo-treatment, temper, and finish machining. Characterization of a test ring and a metallurgical sample after each manufacturing step allows tracking of residual stress and microstructural changes along the sequence. The results presented here are particularly interesting because the highest compressive residual stresses appear after removal of copper masking, not after quench as expected. Data can be used for future ICME models of the heat treat and subsequent machining steps. Analytical methods include X-Ray Diffraction, optical and electron microscopies, mechanical testing, and hardness testing.

Lesley is currently leading the Conferences/Presentations Subcommittee of ASM - RSTC

The Conferences/Presentations Subcommittee is focused on identifying domestic and international conferences that provide opportunities for sharing residual stress knowledge. Our subcommittee also organizes and runs residual stress symposia and sessions at these conferences.

See bio next page

UPCOMING CONFERENCES

Aeromat 2022, Mar. 15, 2022
https://www.asminternational.org/web/aeromat

ICRS 11, Mar. 27, 2022, (Nancy)
https://sf2m.fr/events/icrs-11/

SAE WCX, Apr. 5, 2022
https://www.sae.org/attend/wcx/call-for-papers

SEM , Jun. 13, 2022
https://sem.org/annual

Int Conf on Shot Peening (ICSP), Sept. 4, 2022, (Milan)
https://www.icsp14.org

IMAT 2022, Sept. 13, 2022
https://www.asminternational.org/web/imat-2022

Fatigue 2022, Oct. 16, 2022, (Hiroshima)
https://www.showsbee.com/fairs/Fatigue-Congress.html

Int Conf Fracture, Jun. 11, 2023
http://www.icf15.org

Residual Stress Summit (America), TBD
https://rssummit.org/

LESLEY D. FRAME

Lesley D. Frame is Assistant Professor of Materials Science and Engineering and Director of the Center for Materials Processing Data at University of Connecticut. Dr. Frame received her BS from the Department of Materials Science Engineering at MIT, and she received her MS and PhD from University of Arizona in the same field. Upon completion of her Ph.D. she held postdoctoral positions at The Arizona Research Institute for Solar Energy, and then at Cardiff University and the Rutherford Appleton Laboratory as a Fulbright Scholar where she studied residual stresses using neutron diffraction. Dr. Frame spent five years in industry at Thermatool Corp. leading product development projects, the materials characterization lab, customer technical training seminars, and process improvement efforts for the tube and pipe industry. Her current research is focused on materials processing-structure-property relationships and failure analysis related to metals manufacturing processes, residual stress formation, corrosion, and transient materials properties. She is actively involved in ASM International, and she is the current President of the Heat Treating Society.

ANNOUNCEMENTS

DALE BALL: 2021 LINCOLN AWARD WINNER

http://asipcon.com/pages/lincoln2021.html

Dale's Bio:
https://bit.ly/gotresidualstress202102

Established in 1996, the ***Lincoln Award*** *is given out annually at the USAF ASIP conference to recognize a distinguished career expert who has made significant contributions toward advancements in aircraft structural integrity and safety. Recipients have dedicated their careers to aircraft structural integrity through contributions to research and development, engineering, or applications. Many recipients are technical experts on topics related to fracture and fatigue.*

Submitted by Adrian DeWald