MECHANICAL ENGINEERING STUDENT SEMINAR

Wednesday, March 15, 2023, at 13:30, D. Dan and Betty Kahn Building, Auditorium 1.

Mechanical, thermo-mechanical, and metallurgical comparison between WAAM and bulk SS316L

Gil G. Goviazin

Advisers: Prof. Daniel Rittel and Dr. Amnon Shirizly

Among many other additive manufacturing (AM) methods, wire and arc additive manufacturing (WAAM) is an additive manufacturing (AM) method suitable for large parts. A part is built by melting a wire, driving the melt pool to construct the final geometry. An additional application consists of building the pre-formed shape and then plastically deforming it into a final shape, hence saving material. Previous work revealed a significant strength increase after flow-forming (plastic deformation) as opposed to the as-built material.

In this work, the following properties of WAAM 316L and bulk stainless steel were systematically investigated and compared, to be reported in this seminar:

- Basic material mechanical properties under various strain rates (~10^{-3} and ~10^{3}) and loading regimes (tension, compression, mixed shear modes), in the 3 principal directions.
- The physical mechanism(s) responsible for the ultimate stress increase after large plastic deformation.
- Residual stress reduction and the influence of the temperature on the resulting mechanical properties.
- The thermo-mechanical coupling (expressed by the Taylor-Quinney coefficient - TQC) of WAAM materials.

A servo-hydraulic machine was used for low strain rates. Synchronized high-speed infrared (thermal response) and optical cameras with Split Hopkinson Bar apparatus (mechanical response) experiments were used for the high strain rate characterization.

Two novel observations were made, namely:

- A counter intuitive anomaly was found that, as the heat treatment temperature was increased, the *residual stress decreased but the ultimate stress increased* at the same time, probably because of nano-twins' evolution that were found using electron microscopy. This allowed to define an optimal heat treatment cycle for the relief of residual stresses.
- Although the WAAM material exhibits plastic anisotropy, the TQC was found to be a material property that is isotropic despite the plastic mechanical anisotropy, a point that was never considered, or taken for granted, before that work.

Seminars Coordinator: Assoc. Prof. Matthew Suss.