

X-Ray Diffraction to Predict Stronger Welds in Reactor Steel

Scientific Achievement

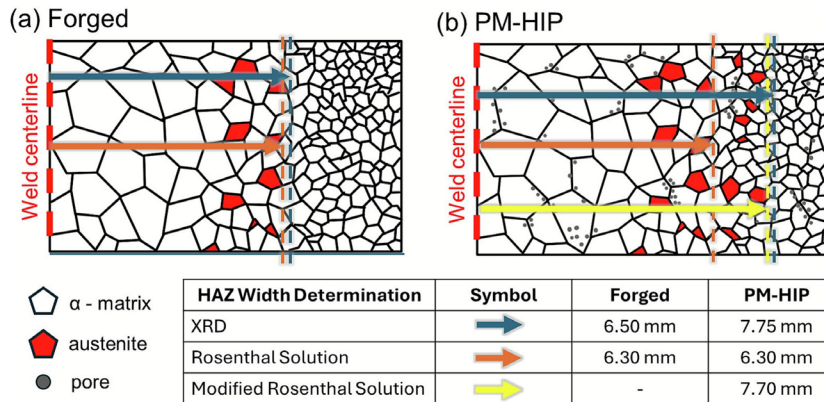
Scientists demonstrate how manufacturing and heat treatment shape weld structure in reactor steels and introduce a more accurate model to predict heat-affected zones (HAZs).

Significance and Impact

Improved prediction of weld performance could enable safer and more reliable designs of nuclear reactor components and other advanced manufactured materials.

Research Details

- Synchrotron X-ray diffraction detected tiny structural changes, improving predictions of long-term reactor vessel performance.
- Advanced heat treatment removes retained austenite and improves uniformity for a more consistent hardness.
- The new model accounts for pores in the material to accurately predict the size of the weld-affected area, matching measurements within less than 1% error.



This chart compares how wide the heat-affected zones (HAZs) are using three different methods: Synchrotron X-ray diffraction (XRD) measurements (green arrows), a standard heat-flow model (Rosenthal equation) (orange arrows), and a new, modified version of that model (yellow arrows). These methods were used on two types of samples: (a) forged and (b) powder-based (PM-HIP) samples, both after heat treatment. Red segments represent austenite and tiny green spots represent pores.

Emerson, J. N., Marrero-Jackson, E. H., Nemets, G. A., Topsakal, M., Gill, S., Wharry, J. P., & Okuniewski, M. A. (2026). Influence of fabrication on microstructure and heat affected zone width in weldments of nuclear reactor pressure vessel steel.

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