FEA Correlation of 3D Scanned Model of Cast Porosity (ACRC)

Overview

Casting aluminum alloys have a heterogeneous nature which is primarily due to process-induced porosity. Pores possess spatially varying morphology and distribution and are generally as a result of gas or shrinkage. Their existence considerably impairs alloys' properties in high-performance applications. It is for this reason that ACRC is focusing on using finite element models and tomography reconstruction techniques to quantify the impacts of pores on cast components and helping industry to have a better understanding of pores with different characteristics.

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Category: Funded by ACRC Consortium

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Project overview:
Process-induced pores are generally small in size and complex in morphology. Integration of their actual geometry into a traditional finite element model often leads to a large number of small-sized and ill-shaped elements. Solving such model is computational challenging, because it requires not only a significant amount of computer memory storage but also prohibitively long simulation time. To resolve the computational challenges, ACRC research team aims to extend existing finite element method by developing mechanistic reduced-order model and machine learning-based surrogate model.
Reduced-order models reduce computational costs while maintaining a high accuracy and versatility by minimizing the number of unknown variables. With fewer variables in a system, the model can be executed with lower memory storage and shorter simulation time.
Machine learning-based surrogate models further improve computational efficiency by conducting expensive simulations in an offline step which dramatically accelerate online calculations. In this process, a database of porosity-oriented material properties is generated via the offline simulation and applicable to various cast components with distinct pore characteristics. Surrogate models coupled with microstructure characterization and reconstruction algorithms can mimic a more realistic pore representation from which the significance of different pore geometrical descriptors is identified via sensitivity analyses.

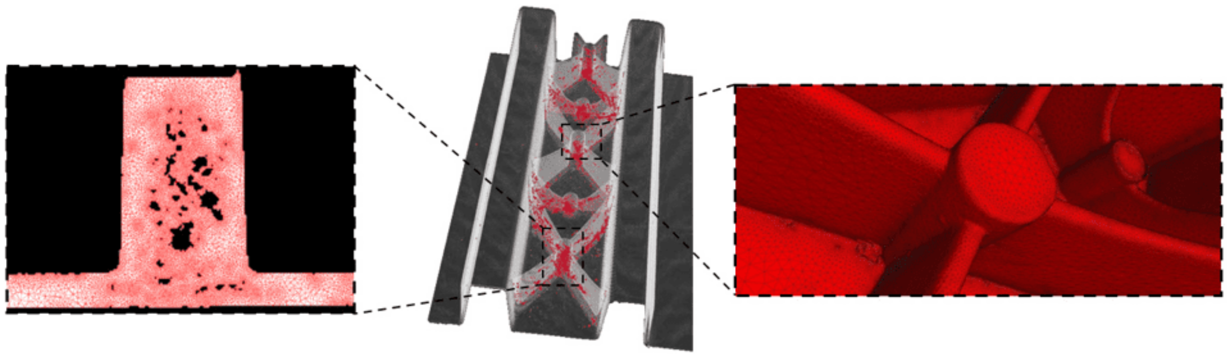

Figure 1: A high pressure die casting (HPDC) manufactured metallic component is detected with more than 1300 pores whose morphologies and spatial distributions are reconstructed from 3D X-ray tomography. Integration of such pores into classic FEA generally needs an extremely fine mesh and prohibitively high computational expense. ACRC research team resolves this computationally demanding problems via reduced order models and machine learning based surrogates.