GRADUATE STUDENT RESEARCH SEMINAR SERIES (2021)

MEASURING ADDITIVE MANUFACTURING RESIDUAL STRESSES USING THE CONTOUR METHOD

SPEAKER: MUHAMMED KOSE

Poly(methyl methacrylate), or PMMA, has been the supporting structure, in the form of bone cement, for all hip and joint replacements since the 1950s. It is hypothesized that the heat generated by cyclic loading experienced by the hip or joint replacement due to the nature of natural body movement plays a pivotal role in the degradation of these replacements. Prevailing theories for failure have been brought forward, such as the cement's inability to perform while exposed to fat and blood, or attributing its brittle nature to the failure. While these likely play roles in the degradation, the effect of self-heating on the bone cement is not fully understood. It has been identified that bone cement can reach temperatures while under load that start to degrade its tensile capabilities. The goal of this research is to quantify and understand the role of self-heating on the degradation of mechanical properties of bone cement. Due to the potential for behavior altering voids in bone cement as it is hand mixed, PMMA is being used for initial characterization. Commercial PMMA is manufactured through extrusion creating a homogenous material.

The present work displays the results of creep experiments which will be used to develop a heat generation model that can predict heat flow through polymers in tension-tension loading scenarios. Alongside the experimentation, possible cyclic loading failure modes were gathered from literature and are examined. Future work will consist of cyclic experiments in tension-tension loading measuring heat propagation through thermography, deformation with digital image correlation, and examining how the bone cement compares in strain, elongation, and self-heating properties such as to validate our previous findings with the PMMA.

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