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Analysis of thermo-mechanical stress in large specimens

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Abstract

Aim: This study focuses on the analysis of thermo-mechanical stresses in large-size cryobags, with the long-term goal of predicting the likelihood of fracture in verification processes. Previous studies have demonstrated that the maximum level of stress is reached at the early stages of rewarming, which outlines the current path of investigation. Method: The current study focuses on a pillow-shaped cryobag, having typical dimension of 61 mm, 61 mm and a variable thickness of up to 61 mm, representing variable content volume-cry protective agent (CPA). This study uses the finite elements analysis software ABAQUS to simulate the coupled thermo-mechanical problem. This study uses the CPA cocktail VS55 as a representative cryopreservation medium, which has been well characterized by our research team in recent years. Results: For a single stage rewarming, the maximum stress was found at the volumetric centre of the cryobag. However, other thermal protocols may lead to a maximum stress at the edge of the bag. The maximum stress decreased between 5.5% and 79%, depending on geometric parameters, when an intermediate temperature-hold period at -110°C was introduced during rewarming. It is further demonstrated that the mechanical stress can be dramatically reduced with the incorporation of volumetric heating, such as nanoparticles in an oscillating magnetic field. Conclusions: From a thermo-mechanical perspective, it would be advisable to fill the cryobag with the minimum amount of CPA and to maintain as flat as possible. Volumetric heating can reduce rewarming-phase thermo-mechanical stress.

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Biography

Prem K Solanki is a Master's degree student at Carnegie Mellon University and is advised by Professor Yoed Rabin. He has completed his Bachelor in Mechanical Engineering from the Birla Institute of Technology and Science in India. His primary interest includes Heat Transfer and he has previously worked on projects entitled "Applications in advanced manufacturing systems, passive cooling systems, and specialized vehicle systems".