Fracture analysis of the battery cans for Implantable Pulse Generators

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Abstract: The stresses in a battery housing used in Implantable Pulse Generators (IPGs), also known as pacemakers, were investigated using Abaqus/Standard. There were three levels of analysis: the global level, the three-dimensional submodel level and the plane strain submodel level. The output of the global analysis was fed into the three-dimensional submodel analysis and subsequently the output of the three-dimensional submodel analysis was fed into the plane strain submodel analysis. The simulation results of the global model were used to drive the more detailed three-dimensional submodels on long and short sides of the battery models. The material properties of the heat affected zone and fusion zone were incorporated into the more detailed three-dimensional submodels. The geometry for the battery housing was also enhanced in the three-dimensional submodel. From the three-dimensional submodel analyses, the displacements of several key points were recorded and imposed on the plane strain submodels. The plane strain submodel included details of the notches, whereas the three-dimensional submodels did not. Ultimately, the finite-strain fracture analyses were conducted on the plane strain submodels and J-integral values were extracted. The J-integral results on the long and short sides were compared and it was found that the J-integral values on the long-side are higher than the corresponding values on the short-side. This was consistent with the experimental observations.

Keywords: Pacemaker, Global-local modeling, submodeling, Fracture mechanic, Implantable Medical Device , Biomedics, Experimental Verification, Welding.

1. Introduction

Medtronic CRDM designs and manufactures cardiac rhythm management products, such as pacemakers and Implantable Cardioverter Defibrillators (ICDs). Both pacemakers and ICDs make use of an internal battery to provide power to the devices. The battery cases can be subjected to internal pressure which can cause stress risers at the weld locations in the battery cases. This pressure develops after end-of-service of the device, when access anode material reacts with the electrolyte in the battery. Although this phenomenon happens only after the battery has been discharged to the point where device replacement is recommended, Medtronic ensures that the device is still safe for the patient. Hence, minimizing potential fracture in the battery cases is of great interest to Medtronic. Numerical modeling was used to analyze the mechanics of the battery