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Thermal and Mechanical Analysis of Electromagnetic Loading on Stainless Steel Structures

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In high voltage applications that require a resistive load or shunt, one must turn to non-traditional resistor construction techniques to satisfy electrical power absorption and load matching requirements, handle thermal loads, and resist distortion and destruction due to generated Lorentz forces. A readily available material that meets these requirements is 304L stainless steel. Pipes constructed of 304L stainless are available in multiple diameters and lengths which allow one to satisfy electrical design considerations; in a coaxial configuration that minimizes the electromagnetic fields exterior to the shunt. Because of Ohmic heating during high current operation of the shunt, it is important to thoroughly analyze and evaluate the structure's temperature distribution relative to system integration and operational requirements. In addition, while electromagnetic fields are constrained to the interior of such a shunt, these fields give rise to very strong Lorentz forces on the inner and outer conductors. These forces must be evaluated from a safety and fatigue perspective to make sure that system operation with such shunts does not endanger the system or personnel.

In this presentation, the author proposes a readily constructed, resistive, coaxial shunt from commonly available 304L stainless steel and yellow brass. This shunt is fed by multiple 350 MCM coaxial cables and is amenable to quarter symmetry analysis for numerical efficiency and to reduce computational runtime. The shunt is modeled in a commercially available multiphysics package and excited by current sources that drive each coaxial cable equally. Analysis of the thermal and electromagnetic loading will be presented. Modifications to the shunt to extend operation to higher current levels or duty cycle operation will be discussed.

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