TEMPERATURE-DEPENDENT EM MATERIAL PARAMETERS (EM2)

1. Test Objective

This problem exercises capability of Truchas to recompute the Joule heat in response to significant changes in the values of the EM material parameters arising from their dependence on temperature.

2. Problem Description

An infinite-length, electrically-conductive cylinder is positioned in a uniform alternating magnetic field directed along the axis of the cylinder. The electric conductivity of the cylinder is axisymmetric with one constant The induced EM fields, current, Joule heat, and temperature fields are all 1D, depending only on the radial distance from the axis. This is the same problem as EM1 except that the conductivity and permeability are functions of temperature. No analytic solution exists for this problem.

3. Truchas Model

The axisymmetry is exploited by solving on one quarter of a thin cross-sectional slab that includes some of the free space. Appropriate symmetry conditions are imposed on the symmetry planes. The domain is meshed with an unstructured hex mesh 1-cell thick, and the tet mesh is obtained from it by simple subdivision of each hex cell into 6 tets. Unlike EM2, the hex mesh does *not* include the free space region (void).

Heat conduction is modeled using constant properties throughout the cylinder, with no flux conditions on the symmetry planes, and on the surface of the cylinder.

The characteristics of the magnetic source field are constant throughout the simulation. However the functional form of the permeability and the conductivity are designed to require that the Joule heat be recomputed twice more after the initial computation, the first because the permeability has changed significantly, and the second because the conductivity has changed significantly.

4. Test Metrics

We want to verify that the Joule heat is being computed at the expected times and with the expected results. A constant time step of 5 is used, and output is obtained at every step (20 steps total). Let Q_j $j = 0, 1, \ldots, 20$ denote the Joule heat after step j (0 is the initial Joule heat), and let $\bar{Q}_j$ denote the corresponding reference field. Then the Joule heat will be tested as follows:

(1) $\|Q_0 - \bar{Q}_0\| < \epsilon$;
(2) $Q_j = Q_0$, $j = 1, \ldots, 4$.
(3) $\|Q_5 = \bar{Q}_5\| < \epsilon$;

Date: November 30, 2006.

(4) $Q_j = Q_5$, $j = 6, \ldots, 16$.
(5) $\|Q_{17} = \bar{Q}_{17}\| < \epsilon$;
(6) $Q_j = Q_{17}$, $j = 18, 19, 20$.

The norm $\|\cdot\|$ will be the maximum relative error.

As an additional check we compare the temperature at the final output with reference temperature results, again using a maximum relative error criterion.

All the tests in this problem will be affected by any change to the heat conduction solver and associcated input parameters (because of the temperature feedback to the EM).