THERMAL STRESS ANALYSIS FOR AN OPERATING SOFC STACK

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Thermal stress analysis for a SOFC stack under combined pressure loading, rejected heat, due to stack operation, is presented. An integrated temperature function of the rejected heat generated by the cell as well as ambient temperature settings provided a first hand study of the effects of thermal expansion, stress and deformation for a steady state case. The analysis involved using the temperature gradient across the cells while 20 Amps was being drawn from it. A hot zone was observed in the corner of the cell between the air and fuel outlet with an excursion of approximately 20 °C. The surroundings were set to 750 °C and both were allowed to diffuse into the surrounding geometries. To allow for uniform thermal expansion of the stack without causing erroneous stresses, the constraints were set to allow frictionless expansion in the horizontal plane on the bottom compression plate while also fixing the bottom compression plate in the vertical plane. Fully constraining several points on the plate eliminated horizontal sliding and rotation. The pressure loading was applied to the top compression plate in a uniform fashion. Observations allowed much insight into the displacement and deflection behaviour of the compression plate, cell, seals and interconnect design by Global. This also led to possible optimizations for the unit cell and stack. Stress analyses showed uniform stresses throughout the cell indicating no regions that would undergo failure due to the combined compression and thermal expansion. A unit cell (repeating cell) was also analyzed, without electrochemical-rejected heat over a 10 hour cycle as shown in figure 1. The unit cell underwent thermal expansion and remained approximately at a constant size at peak temperature, then exhibited contraction due to the temperature drop in the thermal cycle. Displacement observations showed maximum expansion and stresses occurring at maximum temperature, however, once the unit cell reached that temperature, minor changes were seen in stress variations and displacements and deflections. Most of the changes occurred in the warm up and cool down phases of the cycle. The maximum displacement regions were situated on the outer areas of the interconnect, mainly in the corners of the manifolds, while the elevated stresses were located around the inlets and outlets of the manifolds. The thermal shock resistance (TSR) for each material was found not to play a factor in how fast the stacks were heated or cooled.

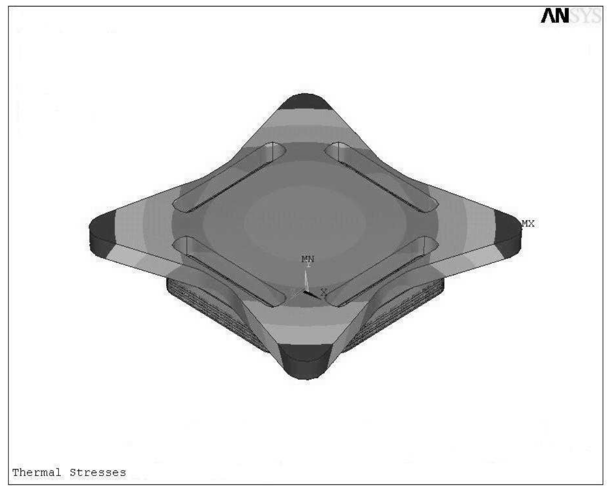

Figure 1. The deflection of the half stack at operating temperature with pressure loading.

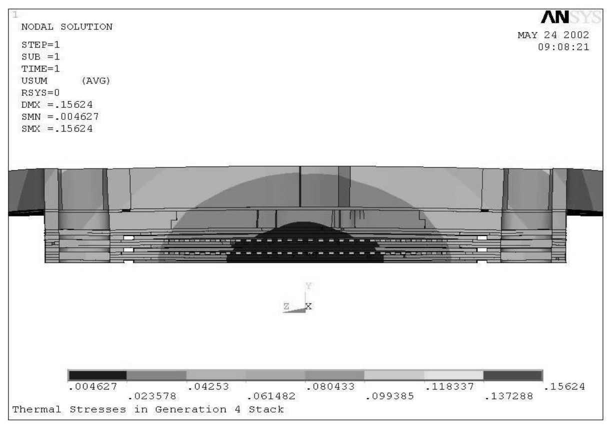

Figure 2. A cut view of the half stack at operating temperature with pressure loading.

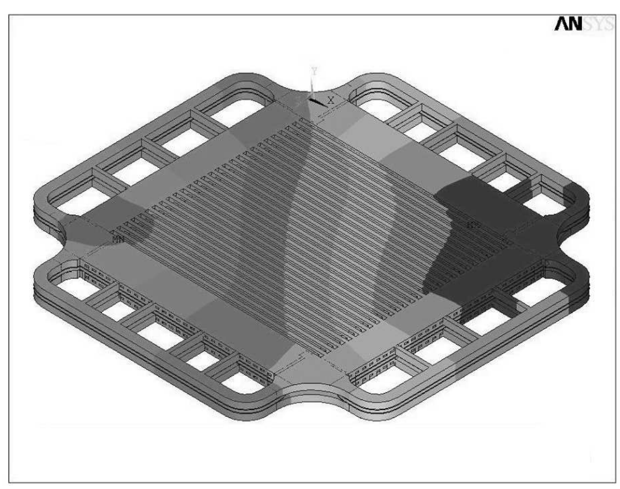

Figure 3. The temperature distribution throughout the unit cell.