Conductor Shape Optimisation Using Thermographic Imaging

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An important consideration in the design of high frequency electromagnetic devices is the effect of conductor shape on current distribution. As a rule of thumb, at high frequency the cross-sectional current distribution resembles a charge distribution in a charged conductor, with current travelling along the surface and particularly along edges. However when other conductors are present the current distribution may change dramatically.

At BHP Research some novel electromagnetic devices are being developed. While the details are proprietary, in one of these the current distribution is an important factor in determining the ultimate performance of the device. Thus we required an experimental technique to analyse the current path. Thermographic imaging was considered because heating is proportional to I^2. The conductors carry very high currents (thousands of ampere) at high frequencies (thousands of hertz) and are water cooled through their hollow centers. Two conductor profiles were tested. These were circular and rectangular, with the rectangular section in two possible orientations, portrait and landscape as shown. Variations in temperature across the conductors of up to 40°C, with equilibrium times of less than one second were observed. It was found that for the circular conductor, the heating was almost exclusively along edge a. This was also the case for the portrait design. The landscape design however was heated fairly evenly about a,b and d, with less heating of c. Calculated current distributions in a finite element model provided qualitative support for these results as did power loss data which showed the landscape design as being the most efficient current carrier and the circular conductor as being the least efficient. For the particular application, the portrait shaped conductor proved to be most effective and this was largely attributable to the current distribution. This experience has shown that thermographic imaging when used appropriately, is a simple way of exploring the current distribution.