Inverse Method for Calculating the Temperature-Dependent Thermal Conductivity of Nuclear Materials

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Abstract

The proposed method uses experimental thermograms obtained via laser-flash heating of a disc-shaped graphite sample in combination with finite element analysis and parameter optimization. The experimental part involves heating samples to a steady state temperature via two lasers (on the back and front sides) and subsequently subjecting the front sample surface to a short laser pulse, resulting in a temperature transient (thermogram). A thermal camera records the temperature transients at 30 points along the radius on the rear surface of the sample. An optimization technique known as the Levenberg-Marquardt method is applied, whereby 5 parameters (emissivity, heat transfer coefficient and three constants k, b, c, representing the thermal conductivity as a function of radius $\lambda = k + br + cr^2$) are altered and used as inputs in finite element software. The parameters are changed until the least square difference between the numerical and experimental thermograms reaches a minimum.

The calculated thermal conductivities at each of the 30 radial points correspond to different temperatures along the surface of the sample and thus a temperature dependent expression for thermal conductivity ($\lambda(T)$) is obtained. The maximum error between the calculated and reference thermal conductivity ($\lambda(T)$) is less than 8%.