Associated with Aerospace Vehicles Development of Methodologies for the Estimation of Thermal Properties

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by

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Thermal stress analyses are an important aspect in the development of aerospace vehicles at NASA-LaRC. These analyses require knowledge of the temperature distributions within the vehicle structures which consequently necessitates the need for accurate thermal property data. The overall goal of this ongoing research effort is to develop methodologies for the estimation of the thermal property data needed to describe the temperature responses of these complex structures. The research strategy undertaken utilizes a building block approach. The idea here is to first focus on the development of property estimation methodologies for relatively simple conditions, such as isotropic materials at constant temperatures, and then systematically modify the technique for the analysis of more and more complex systems, such as anisotropic multi-component systems. The estimation methodology utilized is a statistically based method which incorporates experimental data and a mathematical model of the system.

Several aspects of this overall research effort were investigated during the time of the ASEE summer program. One important aspect involved the calibration of the estimation procedure for the estimation of the thermal properties through the thickness of a standard material. Transient experiments were conducted using a Pyrex standard at various temperatures, and then the thermal properties (thermal conductivity and volumetric heat capacity) were estimated at each temperature. Confidence regions for the estimated values were also determined. These results were then compared to documented values. Another set of experimental tests was conducted on carbon composite samples at different temperatures. Again, the thermal properties were estimated for each temperature, and the results were compared with values obtained using another technique. In both sets of experiments, a 10-15% off-set between the estimated values and the previously determined values was found.

Another effort was related to the development of the experimental techniques. Initial experiments required a resistance heater placed between two samples. The design was modified such that the heater was placed on the surface of only one sample, as would be necessary in the analysis of built up structures. Experiments using the modified technique were conducted on the composite sample used previously at different temperatures. The results were within 5% of those found using two samples.

Finally, an initial heat transfer analysis, including conduction, convection and radiation components, was completed on a titanium sandwich structural sample. Experiments utilizing this sample are currently being designed and will be used to first estimate the material's effective thermal conductivity and later to determine the properties associated with each individual heat transfer component.