Intrinsic Verification and Parameter Estimation

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Engineers must be accurate and correct in the designs and solutions that they present. Accuracy may be an even more important consideration in parameter estimation because sensitivity coefficients involving small differences are needed. The results of inaccurate or incorrect computations can be catastrophic. How can we be sure that our answers are accurate? Intrinsic verification concepts can help to provide assurance that the computations are accurate. In this talk the emphasis is upon the precise analytical solution of transient heat conduction and diffusion problems.

Intrinsic verification is the concept that an analytical solution contains within itself the means for checking that numerical results from the solution are correct and precise. There are several methods of intrinsic verification that have been used to check solutions. Of course, the solution must satisfy the given partial differential equation along with its boundary and initial conditions. These should be analytically satisfied but that does not assure that the program evaluation is correct. It might be that the eigenvalues are inaccurate or some are missing, insufficient numbers of terms in summation are used, or mistakes are present in the program Intrinsic verification is intended to provide assurance that the final numerical values are correct.

A number of principles of intrinsic verification are known. One is that the units in the solution must be consistent, but this says little about the numerical values. Another principle more closely related to numerical accuracy is obtained using two independent methods of solution to obtain precise numerical values. Analytical methods such as the separation of variables and the Laplace transform can sometimes be employed to obtain representations of the same problem. These representations are usually quite different in terms of the functions that are employed and their efficiency in obtaining numerical values in various time regions. The significant point is that the numerical values should be the same to as many decimal places as desired.

The principle of using two different methods of solution given above can be expanded in several significant ways which are to be discussed. One of these is that the solution might have two or more parts, the sum of which gives the complete solution. The two parts might be steady state and transient. For sufficiently small times and away from the heated surface, the temperature rise should be zero. However, the steady state part) is not zero at such times and locations. The complementary transient must exactly cancel the steady state component at these times and locations. This provides a method of verification that applies not only for one-dimensional problems but more complex multi-dimensional problems. Examples relating to parameter estimation are to be given.