APPLICATION EXPERIENCES OF NASTRAN THERMAL ANALYSIS IN ENGINEERING

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ABSTRACT

This paper summarizes the experiences of the application of the thermal analysis phase of NASTRAN in engineering. Some illustrative samples are presented to demonstrate the applicability and limitation of NASTRAN thermal analysis capability in engineering. The results of the evaluation of the relative efficiency, applicability and accuracy among NASTRAN, other finite element programs and finite difference programs are also presented.

INTRODUCTION

Prior to the development of the finite element method, finite difference was one of the most practical analysis techniques for engineering thermal problems. Computer codes such as HEATING, TAP, etc. were developed and widely used. E. L. Wilson and others had shown that thermal problems could also be solved by finite element techniques. Subsequently, several finite element thermal analysis computer programs were developed; most of these were developed as part of a general purpose structural analysis code. For example, [1] John Swanson implemented the finite element thermal analysis method into his proprietary program ANSYS in 1970 and it proved to be extremely popular among the structural engineers.

NASTRAN, being one of the most popular general purpose structural analysis programs, introduced many thermal analysts to finite element thermal analysis techniques. Subsequently, the application of finite element thermal analysis method was widely accepted by engineers and applied scientists. This paper summarizes some experiences of the application of NASTRAN in the analysis of engineering thermal problems.

COMPARISONS OF FINITE DIFFERENCE AND FINITE ELEMENT COMPUTER PROGRAMS

In assessing the relative merits of finite difference and finite element thermal analysis programs, we have to consider computational accuracy, efficiency of input preparation and output interpretation, computer requirements and some other factors. Some experiences are summarized in this section. It should be noted that the information was derived from a limited number of computer runs on currently readily obtainable programs.

In our evaluation of the accuracies of finite difference and finite element we selected several problems of various sizes and types covering ranges of our practical applications. In all cases the desired accuracies were easily obtained by adjusting the mesh or element sizes. Thus, the accuracy comparison by itself does not indicate preference among various finite difference and finite element computer programs.

Input preparation comparisons and output interpretation are more difficult to assess due to various degrees of familiarity with each of the computer codes. However, some distinctive advantages of finite element are evident:

- subsequent utilization of thermal analysis model for structural analysis
- thermal outputs conversion to structural analysis inputs
- program maintenance
- minimizing new users' learning time by running both thermal and structural analyses in one general purpose finite element analysis program.

Computer requirements comparison is based on central memory, I/O and elapsed run time. For small problems, with two minutes or less run time and 140000 (octal) or less core, the relative efficiencies of the finite difference and finite element programs are not significant. However, some problems with run time of five minutes or over and requiring 142000 (octal) core for finite element programs required 300000 (octal) core and about the same run time for finite difference programs. It seems reasonable to project that this difference in core requirement will be widened as the problem sizes increase.

ADDITIONAL DESIRABLE FEATURES

In any computer program some additional features become desirable only after extensive actual applications. Based on our experiences, the following features would be extremely useful to the NASTRAN thermal analysis users:

- Internal Data Generation: During the course of our application of NASTRAN we developed several small programs to generate externally some NASTRAN input cards. After extensive application of NASTRAN and other finite element programs it has become apparent that internal data generation significantly increases users' efficiency.

- Simplification of Radiation Heat Transfer Inputs: The radiation heat transfer input cards RADMTX and RADLST should be simplified to reduce the input data preparation efforts.

- Contour Plot: A simple contour plotting for stress and temperature would be useful for the interpretation of the outputs.

- Addition of a Heat Transfer-Fluid Flow Element: This element is to be defined by two grids, each with only one degree of freedom. It should be capable of transfering heat and fluid between the two grids. The heat transfer should include the heat conduction within the fluid and the mass transport of the fluid.

CONCLUDING REMARKS

Based on our application experience, we have found that the finite element thermal analysis code significantly reduced analyst time and, in most cases, required less computer resources than finite difference codes. Current research and development of finite element programs by various groups is far more extensive than that of finite difference thermal analysis programs. This will lead to an even greater efficiency of finite element thermal analysis programs in the near future. This will provide another incentive for the adoption of the finite element method as a standard thermal analysis tool.