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BURNER LINER THERMAL/STRUCTURAL LOAD MODELLING

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The objective of this program is to develop a thermal data transfer computer program module for the Burner Liner Thermal/Structural Load Modelling Program. This will be accomplished by (1) reviewing existing methodologies for thermal data transfer and selecting three heat transfer codes for application in this program, (2) evaluating the selected codes to establish criteria for developing a computer program module to transfer thermal data from the heat transfer codes to selected stress analysis codes, (3) developing the automated thermal load transfer module, and (4) verifying and documenting the module.

In aircraft turbine engine hot section components, cyclic thermal stresses are the most important damage mechanism. Consequently, accurate and reliable prediction of thermal loads is essential to improving durability. To achieve this goal, a considerable effort over the past 20 years has been devoted to the acquisition of engine temperature test data, as well as the development of accurate, reliable, and efficient computer codes for the prediction of steady-state and transient temperatures and for the calculation of elastic and inelastic cyclic stresses and strains in hot section components. There is a need for continued development of these codes, because the availability of more accurate analysis techniques for complex configurations has enabled engine designers to use more sophisticated designs to achieve higher cycle efficiency and reduce weight.

It has become apparent in recent years that there is a serious problem of interfacing the output temperatures and temperature gradients from either the heat transfer codes or engine tests with the input to the stress analysis codes. With the growth in computer capacity and speed and the development of input preprocessors and output postprocessors, the analysis of components using hundreds and even thousands of nodes in the heat transfer and stress models has become economical and routine. This has exacerbated the problem of manual transfer of output temperatures from heat transfer nodes to stress analysis input to where the engineering effort required is comparable to that required for the remainder of the analysis. Furthermore, a considerable amount of approximation has been introduced in an effort to accelerate the process. This tends to introduce errors into the temperature data which negates the improved accuracy in the temperature distribution achieved through use of a finer mesh. There is, then, a strong need for an automatic thermal interface module.

The overall objectives of this thermal transfer module are that it handle independent mesh configurations, finite difference and finite element heat transfer codes, perform the transfer in an accurate and efficient fashion and that the total system be flexible for future applications.

Based on our study of existing thermal transfer modules, and our experience with our two-dimensional in-house transfer code, three levels of program development criteria were identified.

Level I contains the general criteria which must be satisfied for a usable product. These include:

- Independent Heat Transfer and Stress Model Meshes
- Accurate Transfer of Thermal Data
- Computationally Efficient Transfer
- User Friendly Program
- Flexible System

Level II contains specific criteria which must be satisfied to meet requirements associated with gas turbine applications, such as:

- Internal Coordinate Transformations
- Automatic Exterior Surfacing Techniques
- Geometrical and Temporal Windowing Capability

Level III has criteria which are desirable but not necessary. Total automation of these could be accomplished in future enhancements of the transfer code. Items that fall in this area include:

- Automatic Scaling of Temperatures Based on Engine Power Setting
- Altered Stress Geometry
- Automatic Handling of Temperature Discontinuities

All of the Level I and Level II criteria have been developed and implemented into the thermal load transfer code. This code is being used at General Electric and has been used in conjunction with a three-dimensional model of a combustor liner for the verification phase of this contract. In the verification phase of the contract, 3D heat transfer and stress analysis models of combustor liners and turbine blades were used to validate the mapped temperature produced by the transfer module. Verification cases were made for both finite element and finite difference heat transfer codes. The existing transfer module can process heat transfer results directly from the MARC and SINDA programs and will output temperature information in the forms required for MARC and NASTRAN. The input and output routines in the module are very flexible and could easily be modified to excent data from other heat transfer codes and format data to other stress analysis codes. A user manual for the code has been written and is available.

This thermal load transfer module has been shown to efficiently and accurately transfer thermal data from dissimilar heat transfer meshes to stress meshes. The fundamental part of the code, the 3D search, interpolation and surfacing routines, have much more potential. They form an outstanding foundation for automatic construction of embedded meshes, local element mesh refinement, and the transfer of other mechanical type loading.

3-D TITAN

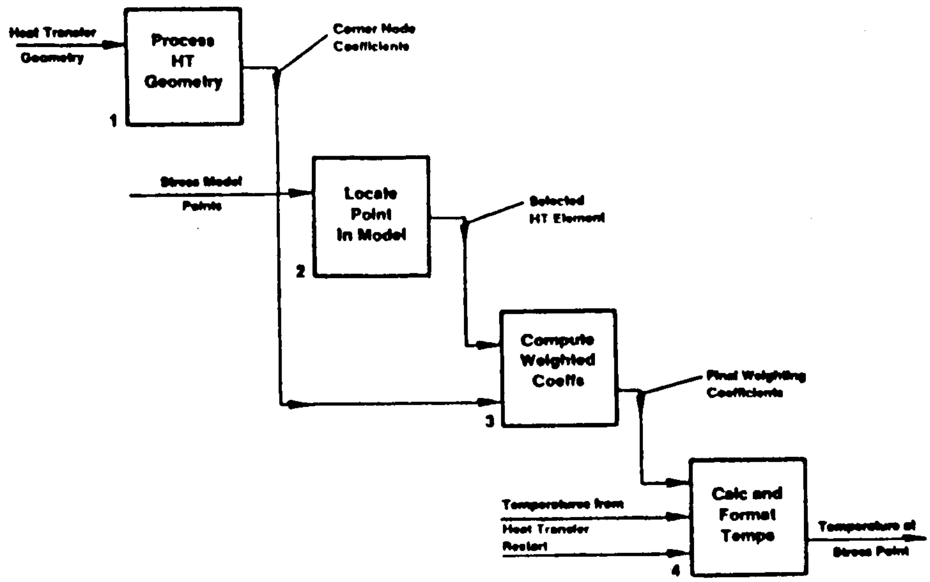
PROBLEM :

- LARGE HEAT TRANSFER/STRESS MODELS
- DIFFERENT MESH DENSITIES
- FINITE DIFFERENCE VS. FINITE ELEMENT CODES
- THERMAL TRANSFER TIME CONSUMING AND ERROR PRONE

Objectives

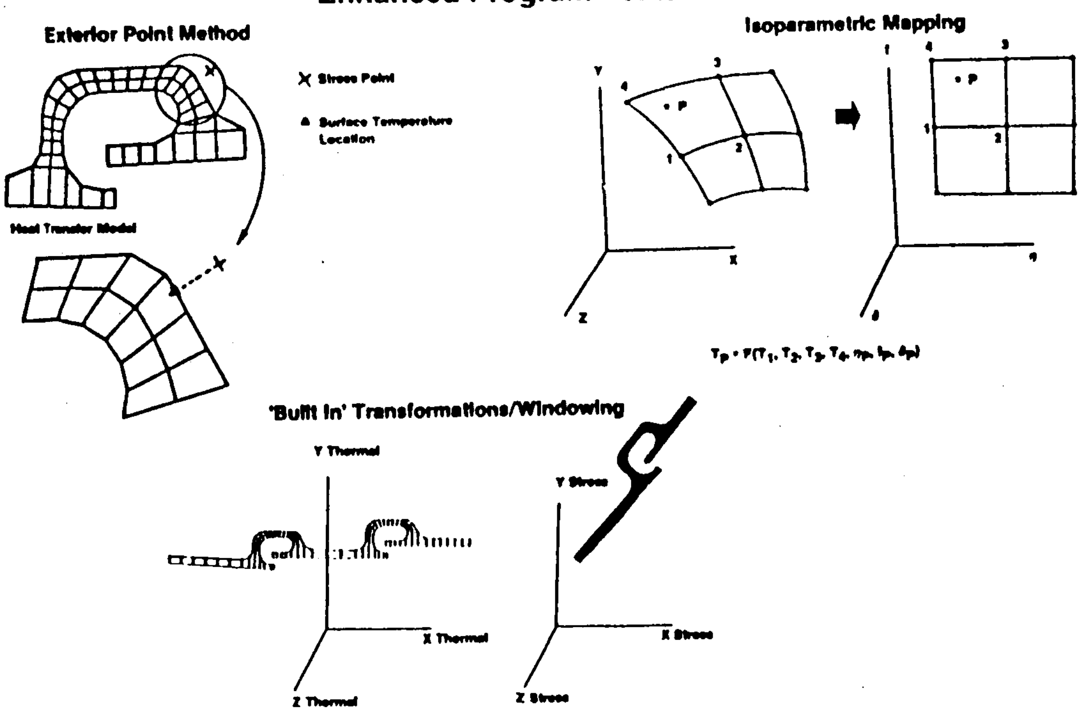
- **Transfer Temperatures from a Heat Transfer Study To a Stress Analysis**
  - **Independent Meshes**
  - **Accurate/Efficient Transfer**
  - **Flexible**

Thermal Transfer Module



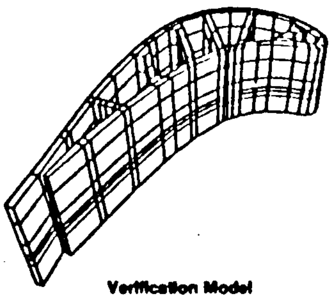
Overall System

Enhanced Program Features

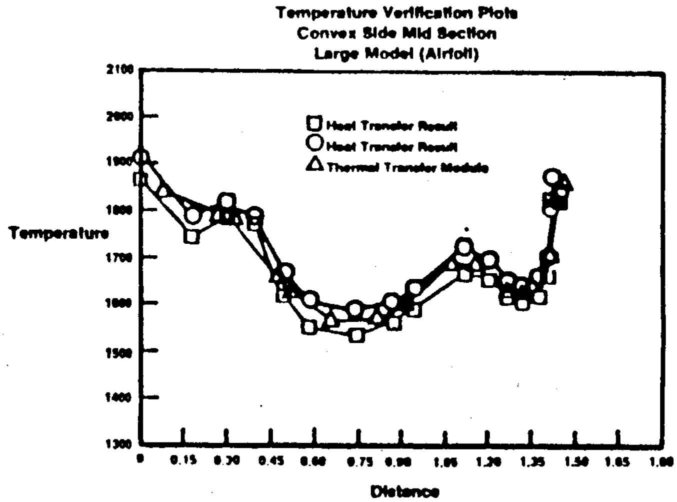


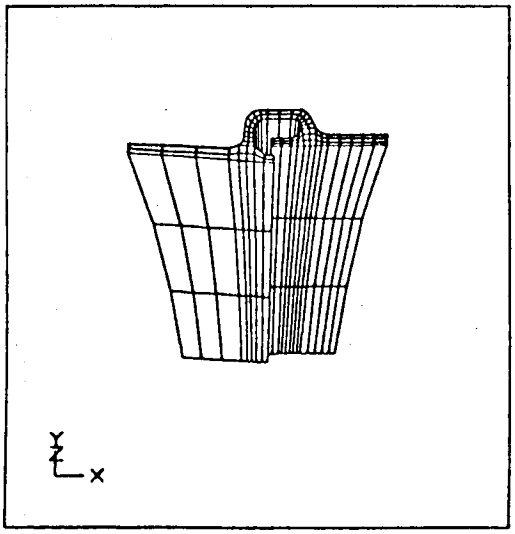
Verification Study

- 415 Heat Transfer Elements
- 827 Corner Nodes

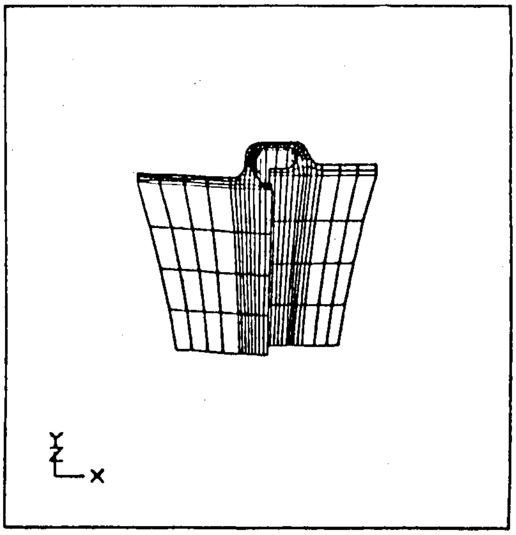


Verification Model

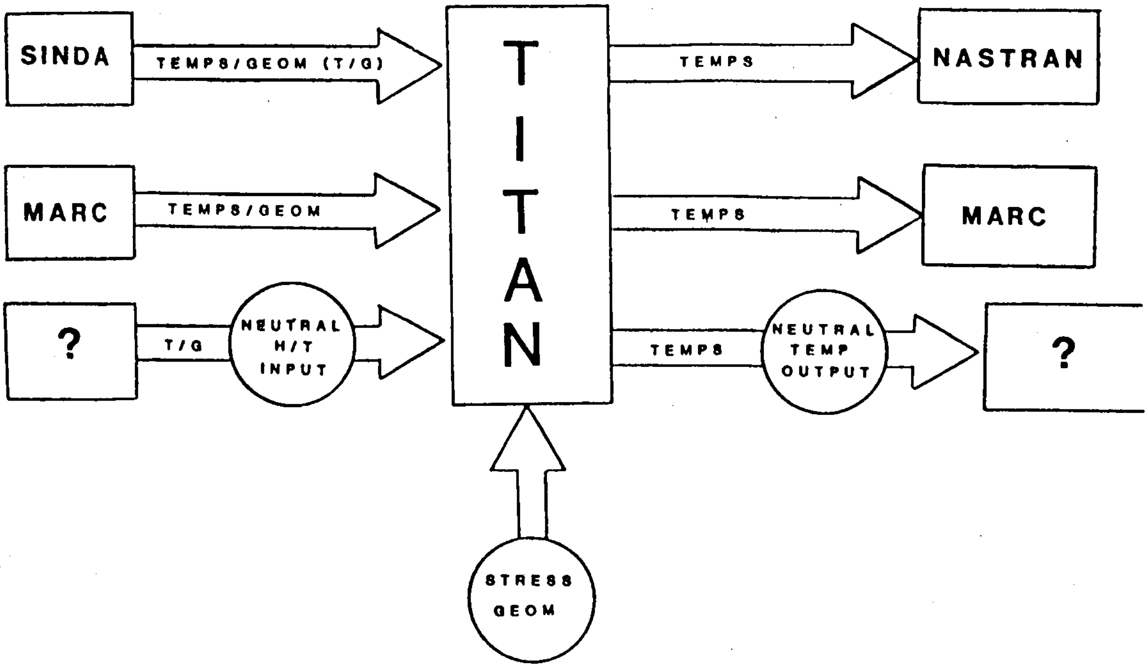




HEAT TRANSFER MODEL



STRESS MODEL



TITAN SCHEMATIC

Future Applications

Automatic Boundary Condition Assignment