USING THE IN-HOUSE LINER CYCLIC RIGS

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The objectives of the HOST Burner Liner Cyclic Rig test program are basically twofold: (1) to assist in developing predictive tools needed to improve design analyses and procedures for the efficient and accurate prediction of burner liner structural response; and (2) to validate these predictive tools by comparing the predicted results with the experimental data generated in the tests. The data generated will include measurements of the thermal environment (metal temperatures) as well as the structrual (strain) and life (fatigue) responses of simulated burner liners and specimens under controlled boundary and operating conditions. These data will be used to validate, calibrate and compare existing analytical theories, methodologies and design procedures, as well as improvements in them, for predicting liner temperatures, stress-strain-responses and cycles to failure. Comparison of analytical results with experimental data will be used to show where the predictive theories, etc. need improvements. In addition, as the predictive tools, as well as the tests and test methods, are developed and validated, a proven, integrated analytical/experimental method will be developed to determine the cyclic life of a burner liner.

Figure 1 includes a list of the test rigs under consideration and the basic liner segments or components to be tested in each rig. Each succeeding test rig and the tests to be conducted in that rig are increasingly more complex than the preceeding one, beginning with a flat plate, then a tube, then a subelement, and finally a full-scale liner test. Correspondingly, the structural analysis becomes more complex in this progression of test configurations. The Quartz Lamp Box Rig, from which experimental temperature and strain data will be obtained, will also serve as the test rig configuration for the evaluation of special instrumentation under development in the HOST program; for example, infrared camera for temperature mapping, thin-film thermocouples, thin-film strain gauges, laser speckle techniques, etc. The instrumentation with the greatest potential will be incorporated and used in the other rigs.

Test conditions and variables to be considered in each of the test rigs and test configurations, and also used in the validation of the structural predictive theories and tools, will include: thermal and mechanical load histories (simulating an engine mission cycle, different boundary conditions, specimens and components of different dimensions and geometries, different materials, various cooling schemes and cooling hole configurations, several advanced burner liner structural design concepts, and the simulation of hot streaks. Based on these test conditions and test variables, the test matrices for each rig and configurations will be established with the intent to verify the predictive tools over as wide a range of test conditions as possible using the simplest possible tests. An illustrative flow chart for the thermal/structural analysis of a burner liner and how the analysis relates to the tests is shown schematically in Figure 2. The chart shows that several nonlinear constitutive theories are to be evaluated.

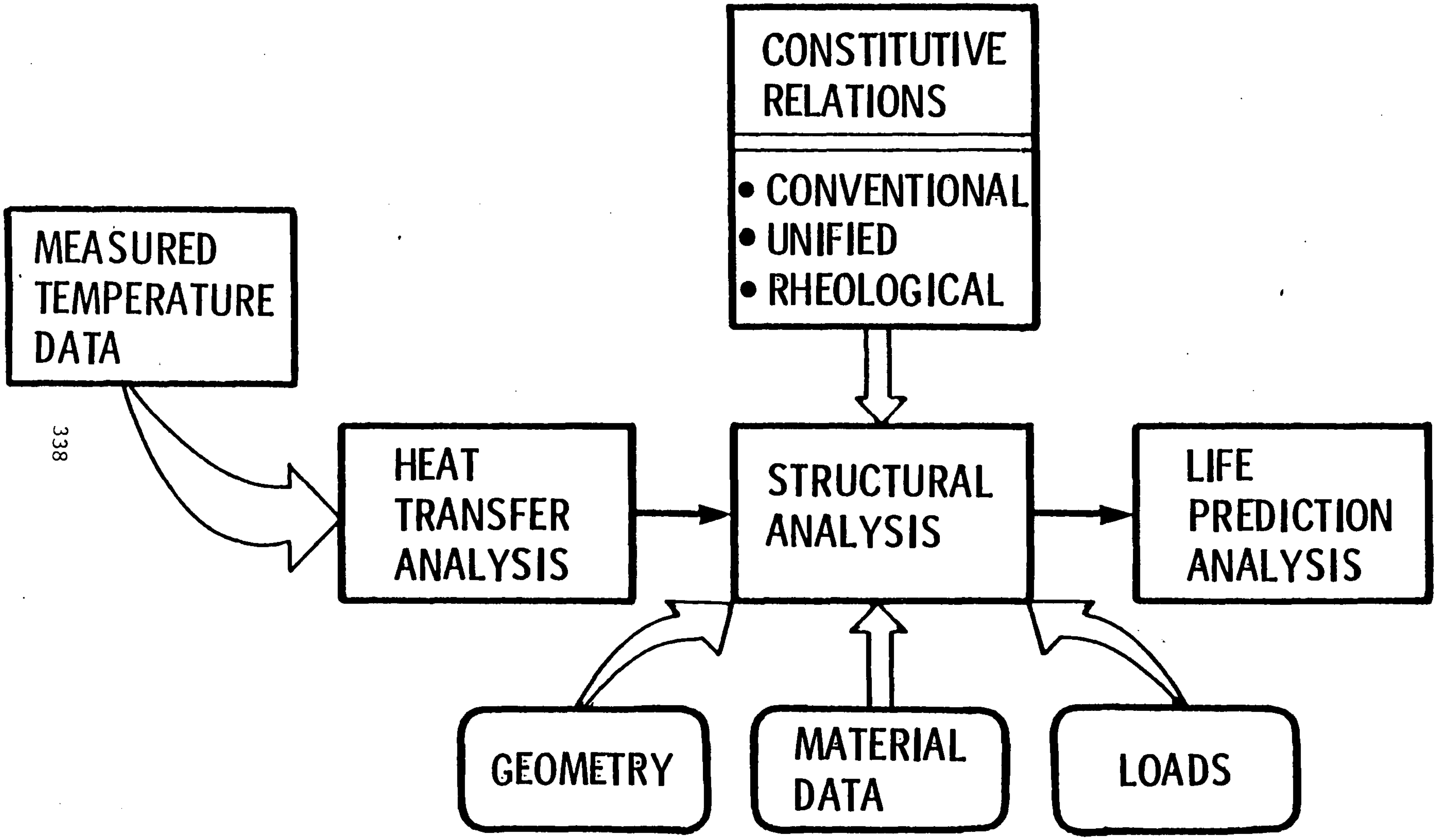
Preliminary structural analyses in which several viscoplastic (unified) theories are being evaluated are underway for a flat plate, an axisymmetric combustor liner (tube) segment and a three-dimensional simulated combustor liner segment, each of which will be tested in its appropriate test rig. The basic elements required for a structural analysis of a flat plate are outlined in Figure 3. Analysis of the axisymmetric liner is just beginning. A representative finite element ring model and an imposed transient temperature distribution are shown in Figure 4. Analysis of a 3-D combustor liner constructed from stacked sheet metal louvers has been initiated. The construction of this combustor liner is shown in Figure 5. A representative symmetric finite element model of one of the segments with cooling holes is shown in Figure 6. In this example, less than 1^o or 1/360th of the inner liner is being modeled. Typical temperature inputs to the structural analysis code, both steady-state and transient distributions obtained from measured data and a thermal analysis, are shown in Figure 7. The predicted strains will be compared with the experimental strains in order to validate the predictive theories for each of these test configurations. In addition, these types of preliminary analyses will also be useful in determining where both thermocouples and strain gauges should be located on the specimens in order to ensure that regions of steep thermal gradients and high stress concentrations are captured in the test measurements. A tentative schedule for completing the structural analyses of these test specimens is shown in Figure 9. As other test configurations are identified in this study, they will be added to this list.

STRUCTURAL ANALYSIS
OF COMPONENTS TO BE TESTED IN HOST LINER CYCLIC RIGS

1. QUARTZ LAMP BOX RIG
    - FLAT PLATE
2. QUARTZ LAMP ANNULAR RIG
    - SUBELEMENT OF COMBUSTOR LINER
    - TUBE
3. LOW PRESSURE CYCLIC CAN RIG
    - FULL-SCALE COMBUSTOR LINER

FIGURE 1

NONLINEAR THERMAL/STRUCTURAL ANALYSIS OF ADVANCED COMBUSTOR LINERS



CONSTITUTIVE RELATIONS

- CONVENTIONAL
- UNIFIED
- RHEOLOGICAL

MEASURED TEMPERATURE DATA

HEAT TRANSFER ANALYSIS

STRUCTURAL ANALYSIS

LIFE PREDICTION ANALYSIS

GEOMETRY

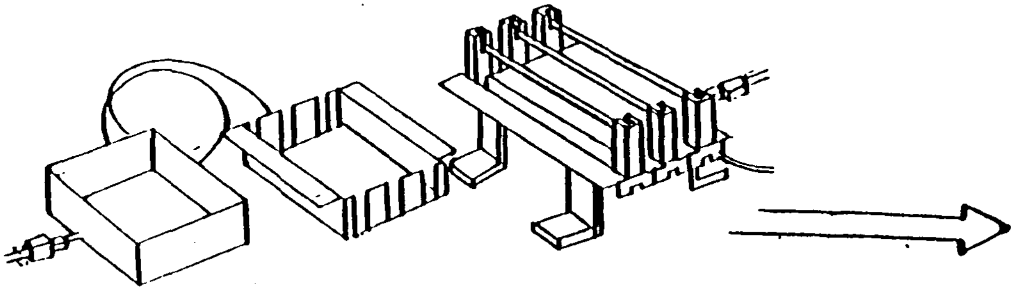
MATERIAL DATA

LOADS

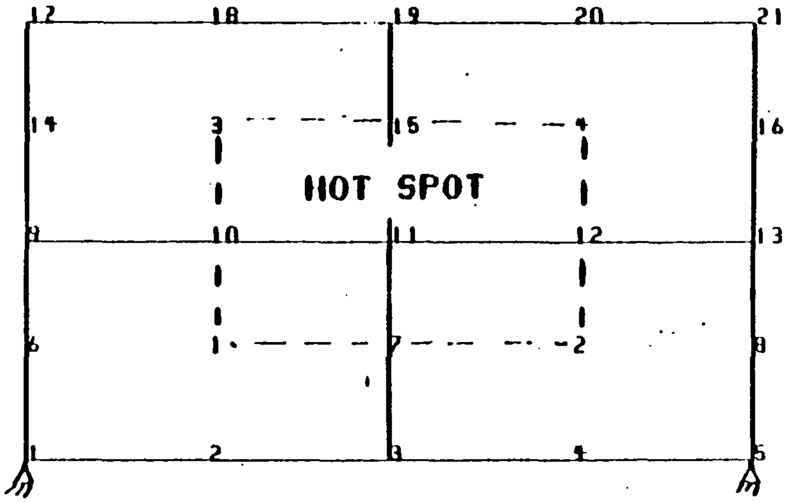
FIGURE 2

COMBUSTOR LINER ANALYSES AND TESTS(HOST)

QUARTZ LAMP BOX RIG

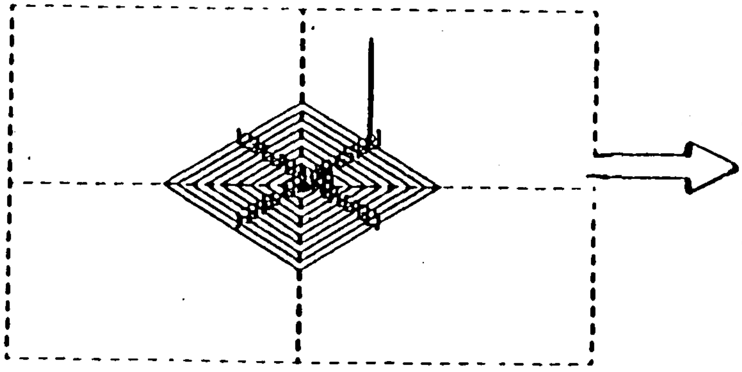


STRUCTURAL ANALYSIS OF FLAT PLATE



IMPOSED TEMPERATURE HISTORY

1 = 1.35E3
2 = 1.38E3
3 = 1.40E3
4 = 1.43E3
5 = 1.46E3
6 = 1.48E3
7 = 1.51E3
8 = 1.53E3
9 = 1.56E3
10 = 1.59E3 .



STRESS/STRAIN CONTOUR PLOTS

1 = -5.34E4
2 = -4.50E4
3 . = -3.67E4
4 = -2.83E4
5 = -2.4-E4
6 = -1.16E4
7 = -3.25E3
8 = 5.11E3
9 = 1.35E4
10 = 2.18E4

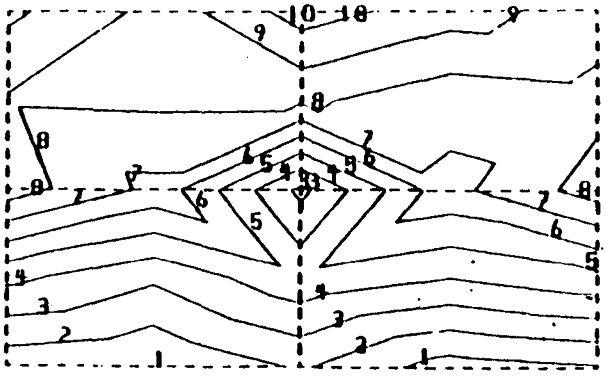
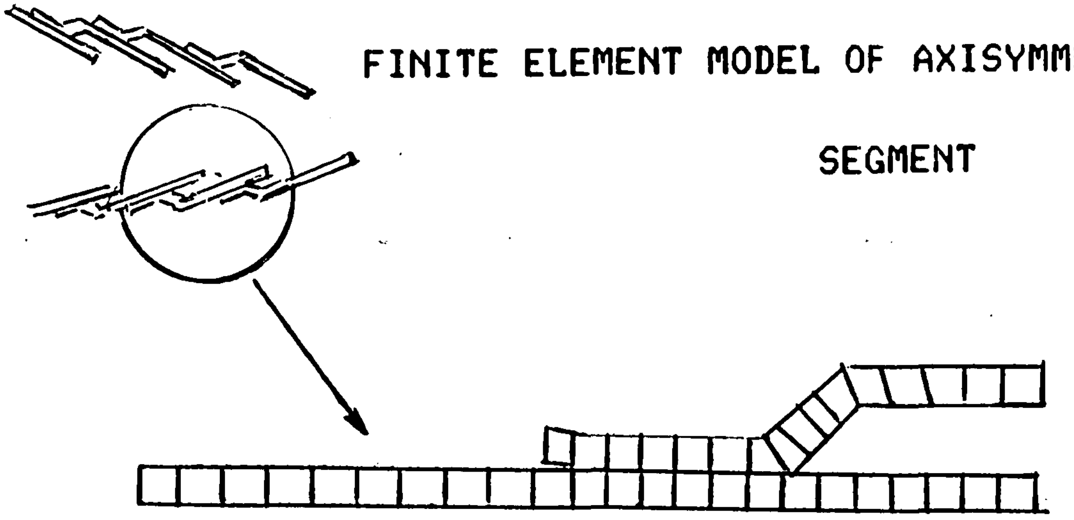


FIGURE 3

FINITE ELEMENT MODEL OF AXISYMMETRIC COMBUSTOR

SEGMENT



LINER METAL TEMPERATURES

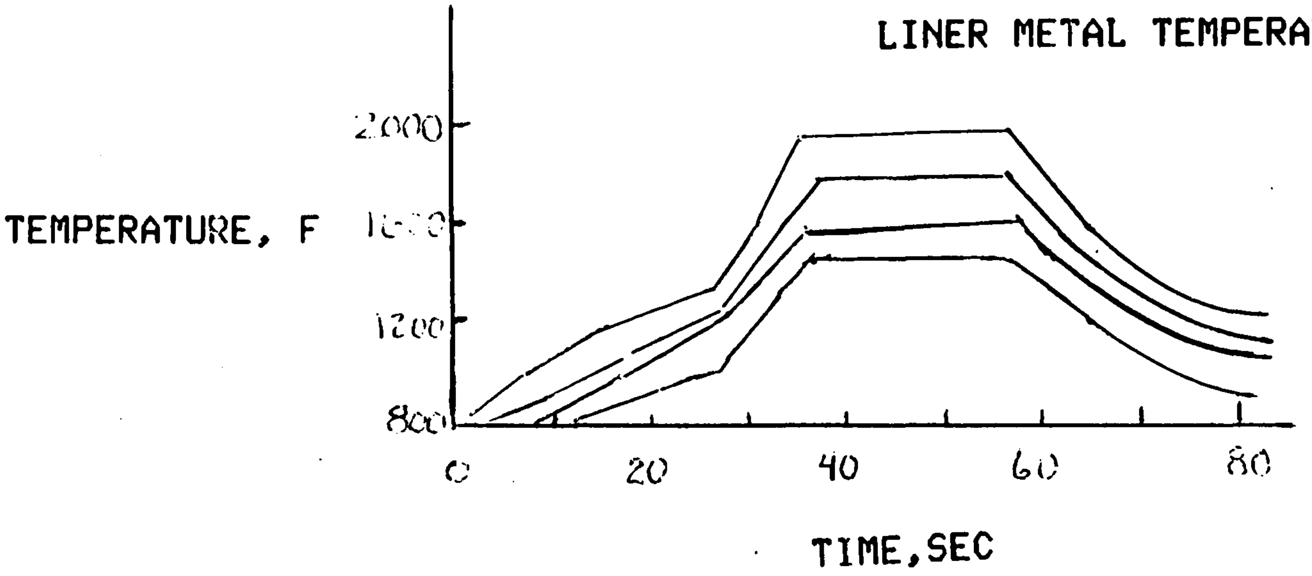


FIGURE 4

TYPICAL LOUVER COMBUSTOR CONSTRUCTION

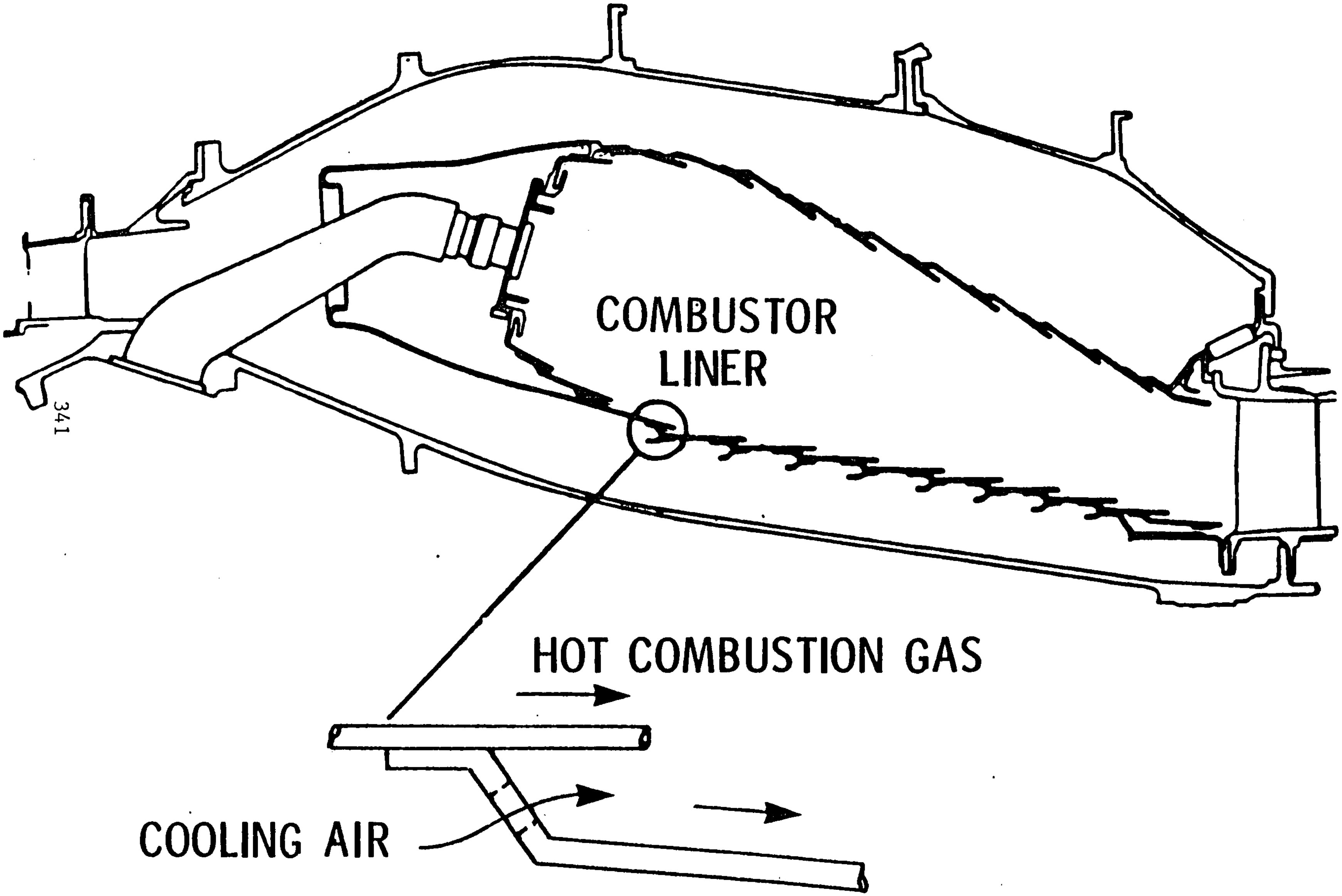


FIGURE 5

LOUVER METAL TEMPERATURES

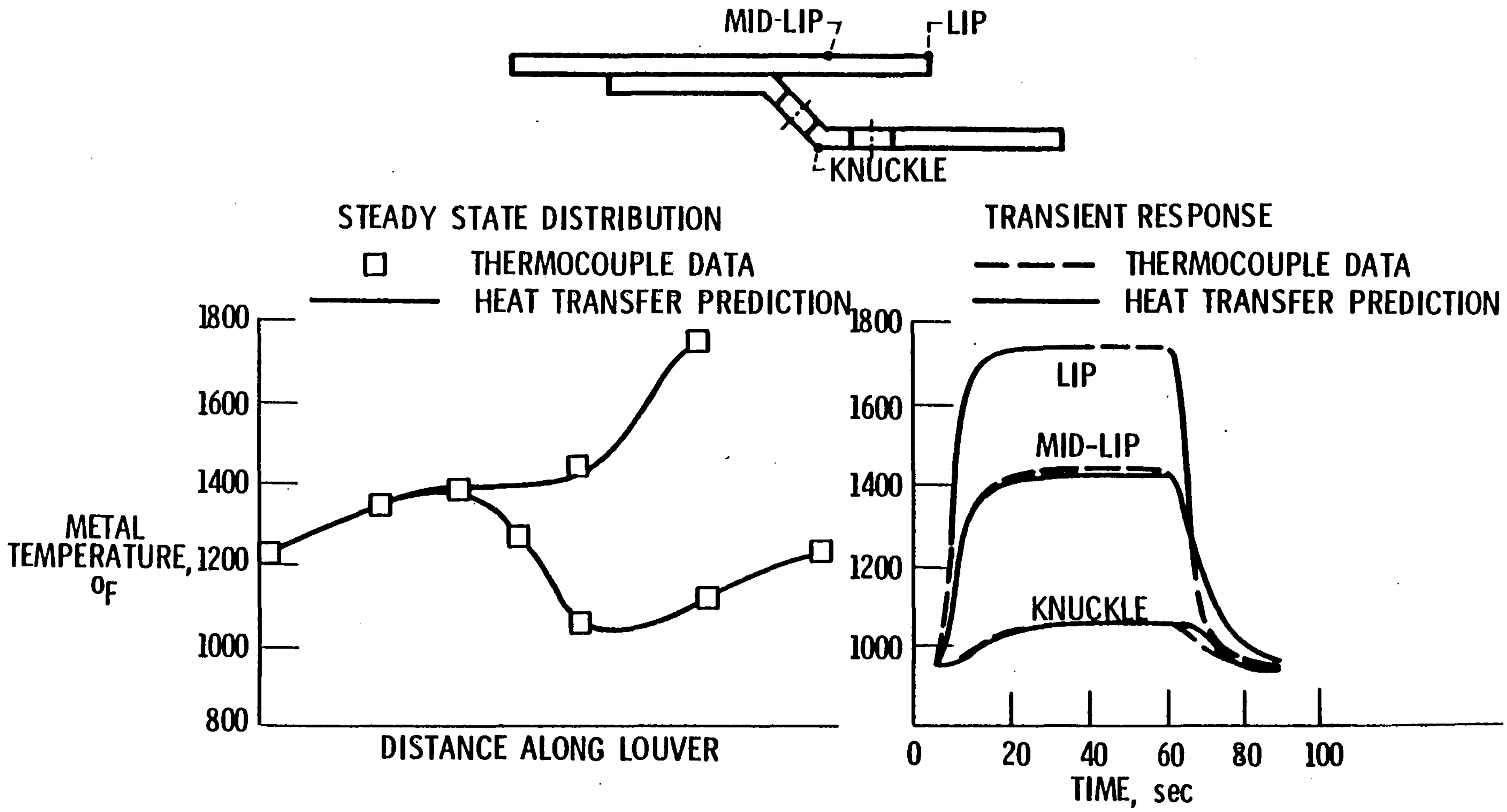


FIGURE 6

FINITE ELEMENT MODEL OF COMBUSTOR SEGMENT

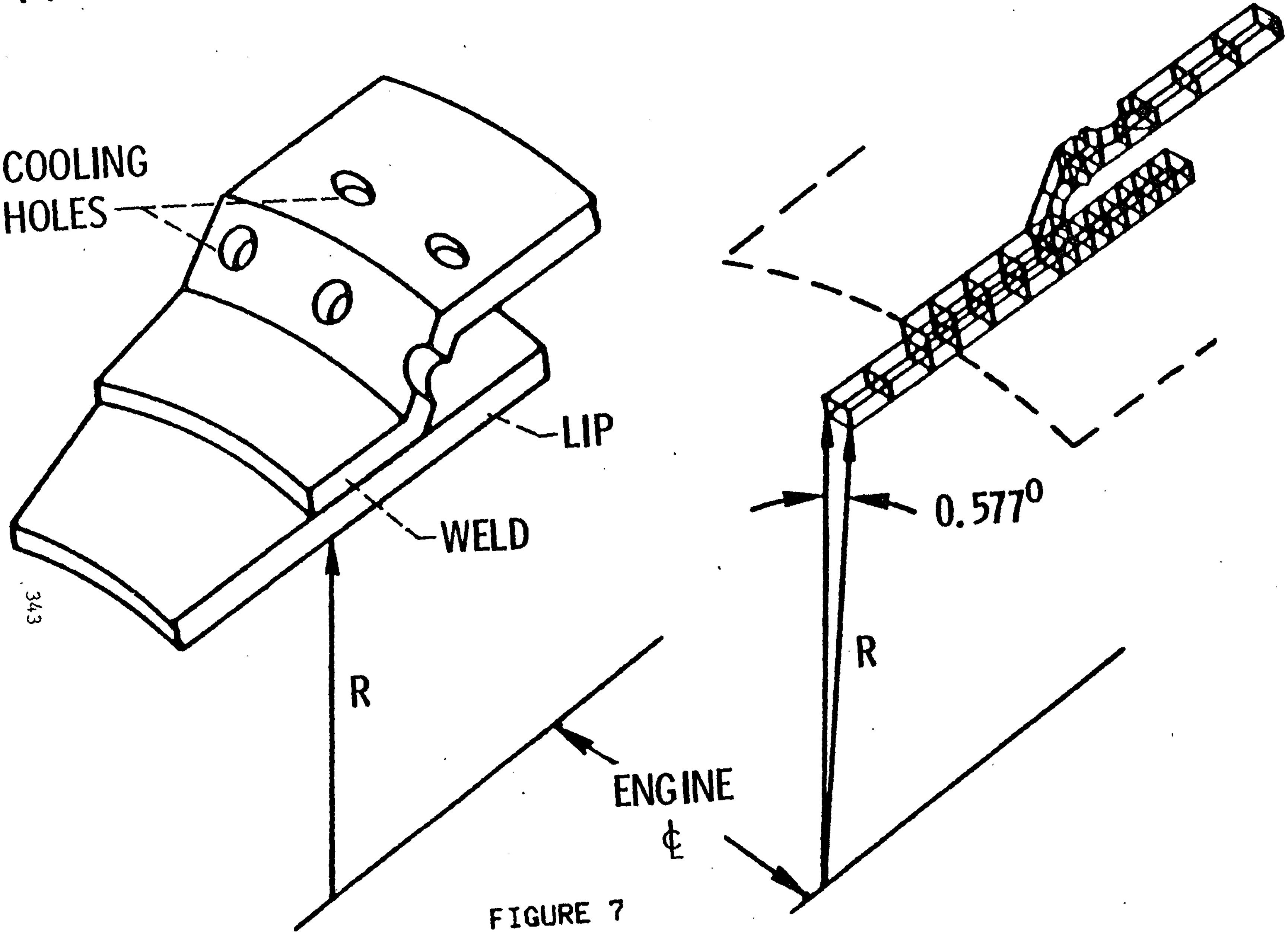


FIGURE 7

SCHEDULE FOR STRUCTURAL ANALYSIS OF COMPONENTS

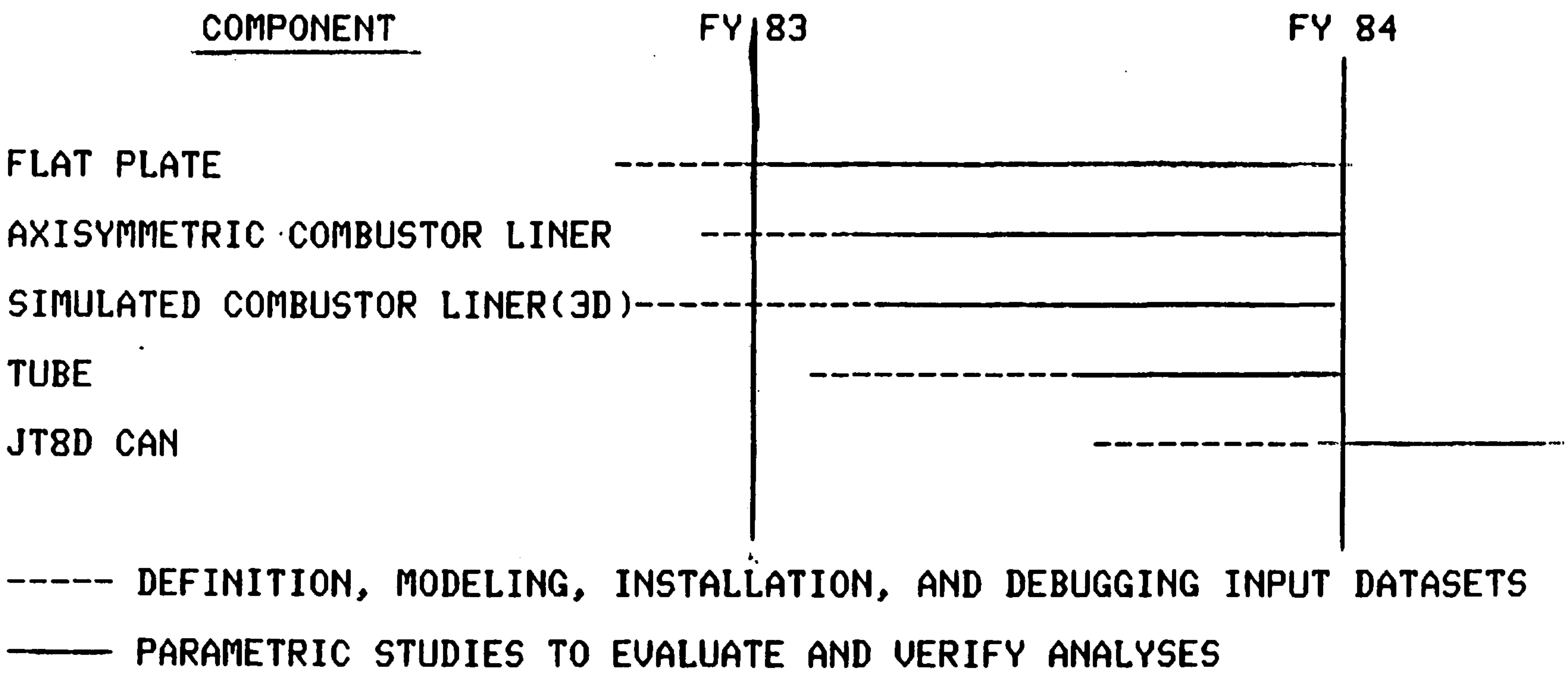


FIGURE 8