1. SUMMARY

A typical example of a nonlinear solver used in several different engine simulation programs will be described, including its interaction with the dynamic and discontinuous aspects of the model.

2. INTRODUCTION

Mathematical models of gas turbine engines, as with other types of nonlinear fluid models, require an iterative solution. The minimum set of iteration variables required for gas turbine engine models can be generalized with the following set of rules :

1. Each stream requires that the inlet flow be an iteration variable and that an exit static pressure boundary condition be maintained.
2. Each shaft model requires that the shaft speed be an iteration variable and that the sum of torques on the shaft be zero.
3. Each rotating component model uses pressure ratio, or some function of it, as an iteration variable while maintaining flow continuity at the component's inlet station.

The flow continuity requirement of rotating component models can be a source of iteration convergence problems at very low speeds. In general, the flow capacity relationship (or map) for compressors and turbines produces relatively large changes in flow for small changes in pressure ratio near zero flow. In order to better accommodate this problem, approaches that modify the conventional map representation (pressure ratio versus corrected flow or flow parameter for lines of constant corrected shaft speed) have been developed.

Compressor maps can be represented by corrected flow versus corrected speed for lines of a constant parameter. Several different parameters, made up of some combination of corrected flow and pressure ratio, have been used in various applications. Each method has the effect of compensating the large pressure ratio to corrected flow influence so as to provide a more normal relationship between the iteration variable and the error term.

Turbine flow functions also become very steep at low flows. In this case, it was decided to break the function up into two separate pieces, one for high flows using pressure ratio as an independent variable and another for low flows using flow parameter (w*sqrt(T)/pA). In the high flow regime, the conventional error term calculated from a flow difference is used. In the low flow regime, this error term is replaced by one in which the pressure ratio calculated from the inverse flow function is differenced with the pressure ratio iteration variable. Again, this has the effect of normalizing the iteration variable to error relationship.

Finally, an unconventional approach to the problem of calculating static pressure, temperature and density as well as velocity given flow, total pressure and temperature and the area at a station has been taken. In this scheme, the static pressure is taken to be