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# TURBINE HEAT TRANSFER

John E. Rohde
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

Improved turbine durability and performance and reduced development cost will all result from improved methods of predicting turbine metal temperatures. As you know, better metal temperature prediction methods require improvements in the methods of predicting the hot gas flow over the turbine airfoils and the cooling air flow inside the airfoil and in the methods of predicting the heat transfer rates on both the hot gas-side and coolant-side of the airfoil. The overall HOST Turbine Heat Transfer effort is directed at improving all four of these areas of concern.

Achievement of these improvements requires a rigorous and systematic research effort from both the experimental and analytical sides. The experimental approach being pursued starts with fundamental experiments using simple shapes and flat plates; progresses on to more realistic cold, warm, or hot cascades using airfoils; continues to progress on to more realistic warm turbine, large low-speed turbine, or transient turbine tests; and finally combines all the interactive effects in real-engine or real-engine type turbine tests. Analytical approaches being pursued also start with relatively simple mathematical models and progress to more realistic cases that include more interactive effects, and finally combines all the interactive effects of the turbine operating in the real engine environment.

The HOST Turbine Heat Transfer Subproject schedule showing the current activities is included in the attached figures. Each line on the figure represents a separate contract, grant, or NASA Lewis in-house effort. The dotted blocks indicate future potential contract or grant activities. Currently, contract and grant efforts are being conducted to obtain fundamental experimental data and to develop and/or assess analytical tools in all four areas of concern. These contract and grant activities will be discussed in detail later in this meeting by the respective principal investigators.

NASA Lewis in-house turbine research efforts are being pursued to obtain more realistic warm turbine and real-engine type turbine experimental data. The major turbine research parameters of interest that will be measured or determined to provide this better understanding of the aerothermal loads on air-cooled airfoils are the following:

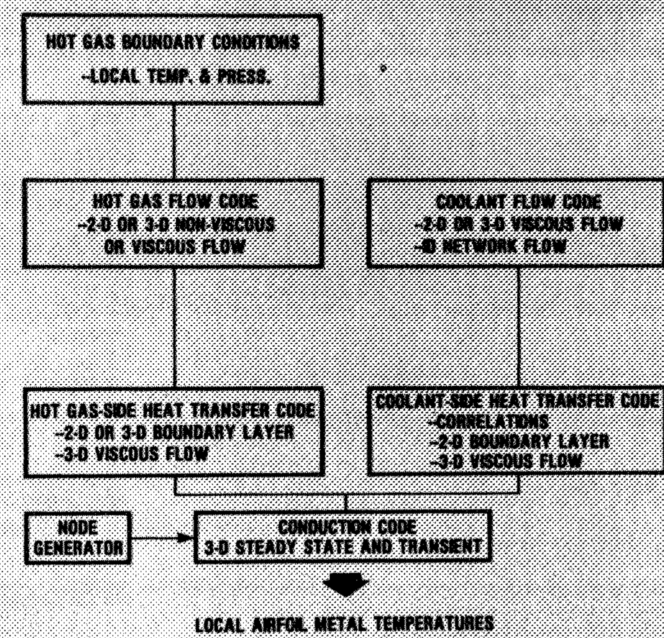
1) local hot gas flow velocities and secondary flows,
2) local hot gas recovery temperature along the airfoil surfaces and other hot gas path surfaces,
3) local total and radiation heat fluxes to the airfoils and other hot gas path surfaces, and
4) local airfoil wall temperatures.

Very little or none of this type experimental research information exists with controlled warm or real-engine type conditions and known boundary conditions.

These in-house turbine research efforts will be conducted using the best available analyses to help define the test configurations, the types of research measurements, and for comparisons with the measured research results. Initially, analytical efforts will use the best available flow and heat transfer codes such as a twoor three-dimensional inviscid flow code and a two- or three-dimensional boundary layer heat transfer code. These analyses will be applied at the mid-span section and possibly at the hub and tip sections or other local zones of the hot gas flow path. More sophisticated three-dimensional viscous codes and three-dimensional viscous codes with boundary layer resolution will be used as they become available. These analytical efforts will be conducted using the best available source or sources in-house and on contract with industry and universities.

An Airfoil Metal Temperature Runoff effort is planned to start in 1985. This Airfoil Metal Temperature Runoff effort will be initiated using an all-impingement cooled static airfoil configuration and a multipass cooled rotating airfoil. Both of these air-cooled airfoils will use NASA conceived profiles and no film cooling initially. This program will provide engine manufacturers with an opportunity, through contracts and/or cooperative agreements, to assess and improve their analytical tools used to predict airfoil metal temperatures. The results of these assessments will be accumulated as an industry uncertainty band from the experimental data with the individual contributors predictions remaining known only to the individual contributor. Contracted contributors would be required to identify the analytical tools used and the uncertainty levels obtained.

## ANALYTICAL TOOLS USED TO PREDICT AIRFOIL METAL TEMPERATURES

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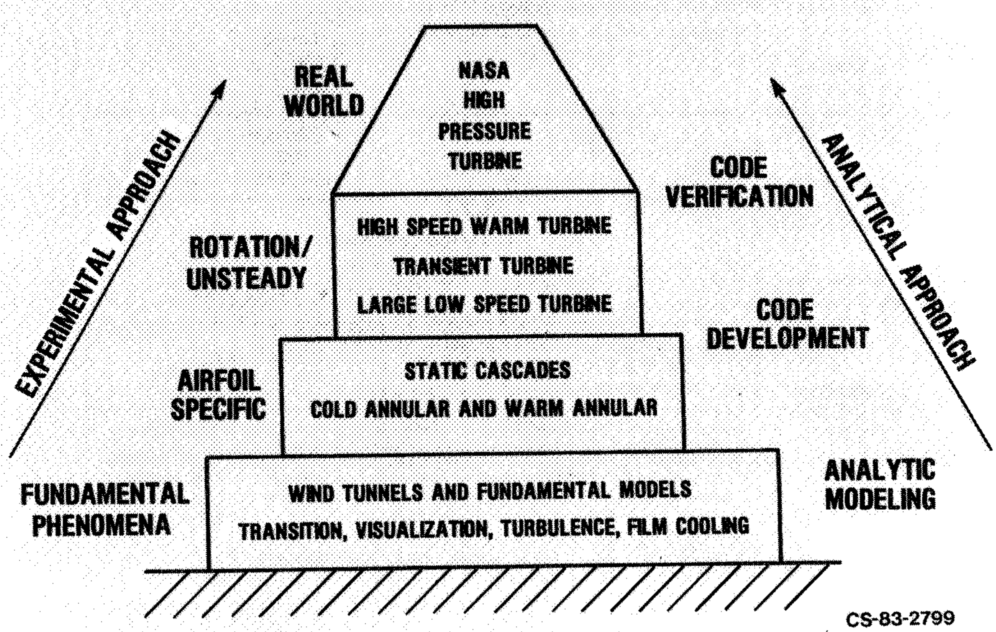
## BUILDING BLOCK AEROTHERMAL TURBINE RESEARCH APPROACH

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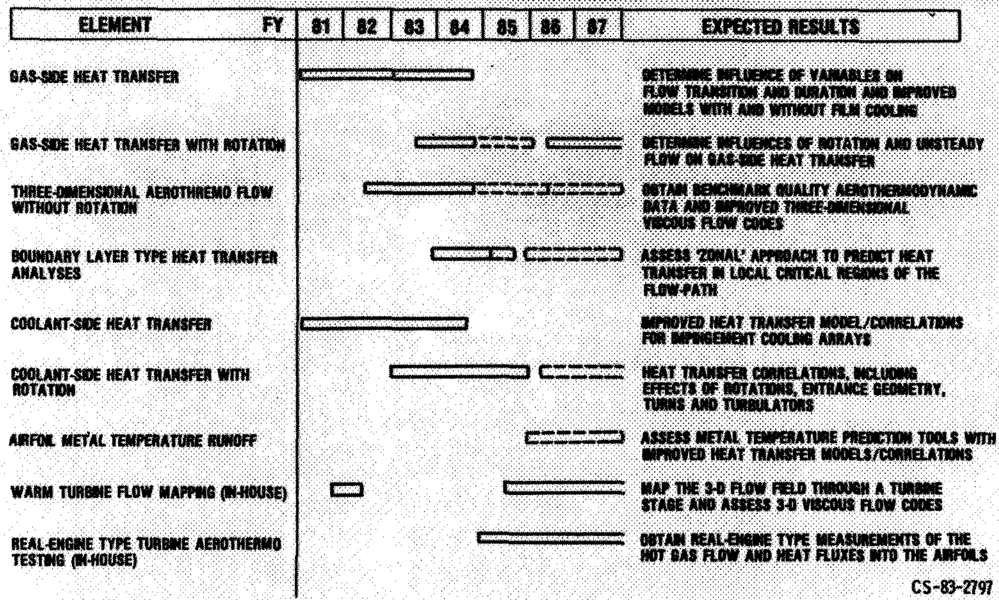
## TURBINE HEAT TRANSFER SUBPROJECT SCHEDULE

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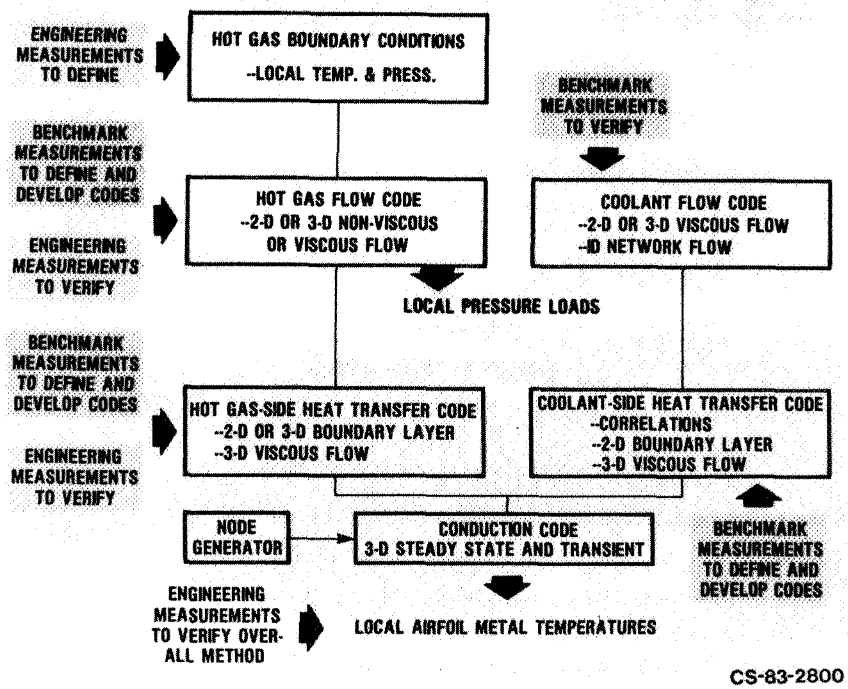
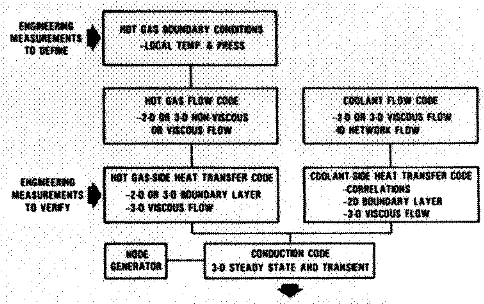


# AIRFOIL METAL TEMPERATURE RUNOFF

**GOAL:** ASSESS AND IMPROVE ANALYTICAL TOOLS USED TO PREDICT AIRFOIL METAL TEMPERATURES

- ASSESS METAL TEMPERATURE PREDICTION USING AN ALL-IMPINGEMENT COOLED VANE WITH NO FILM COOLING INITIALLY
- REVISE ANALYTICAL TOOLS BASED ON REAL-ENGINE TYPE MEASUREMENTS OF THE LOCAL HOT GAS TEMPERATURES AND HEAT FLUXES AND REASSESS VANE METAL TEMPERATURE
- ASSESS METAL TEMPERATURE PREDICTION USING A MULTI-PASS COOLED BLADE WITH NO FILM COOLING INITIALLY

ANALYTICAL TOOLS USED TO PREDICT AIRFOIL METAL TEMPERATURES




- REVISE ANALYTICAL TOOLS BASED ON REAL-ENGINE TYPE MEASUREMENTS OF THE LOCAL HOT GAS TEMPERATURES AND HEAT FLUXES AND REASSESS BLADE METAL TEMPERATURES

**STATUS :** MULITPLE CONTRACTS AND/ OR COOPERATIVE AGREEMENTS TO BE AWARDED IN 1985

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