SURFACE PROTECTION OVERVIEW

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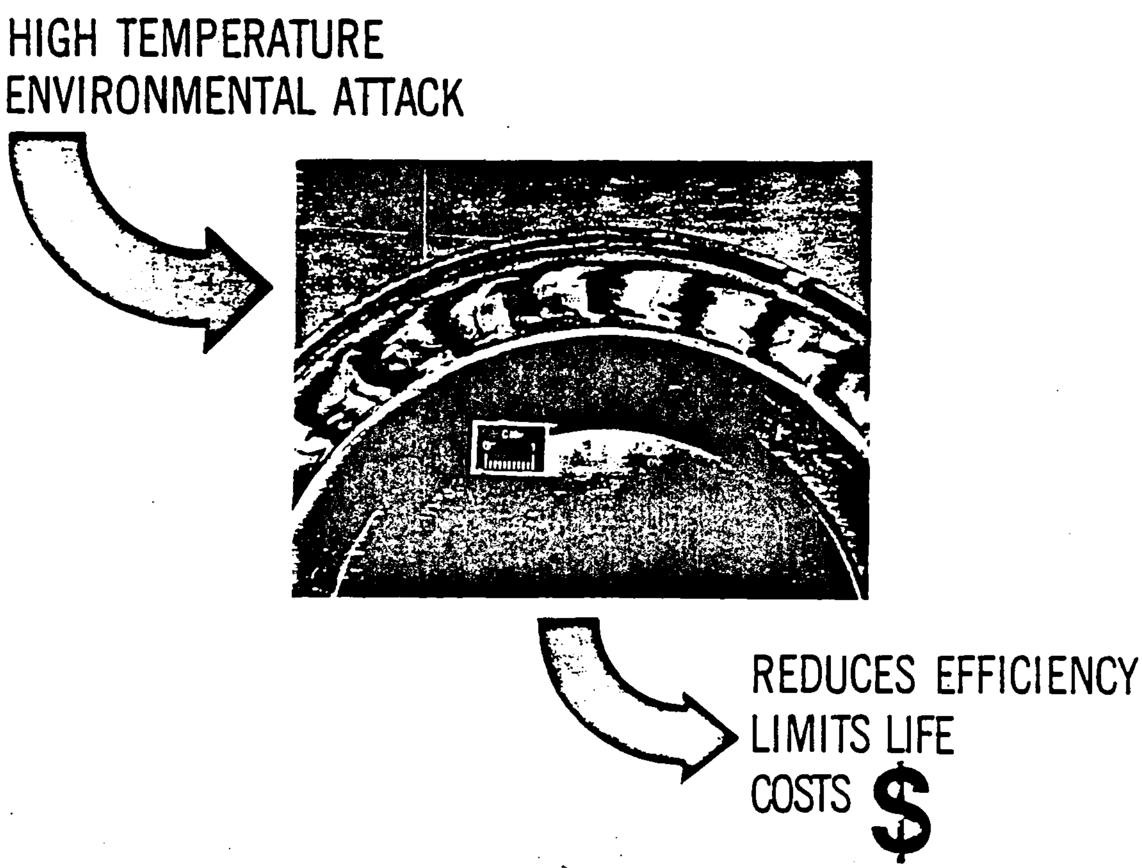
Turbine engine hot section materials are subjected to aggressive chemical and thermomechanical environments. High temperature environmental attack of dollar intensive turbine components reduces turbine efficiency and can limit life. The bottom line, of course, is that high temperature oxidation and hot corrosion attack costs you money. The objective of materials durability research at Lewis is to understand the mechanisms of alloy and coating attack, and the effects of interaction with the environment on mechanical behavior. This base of understanding provides the foundation for developing life prediction methods and identifying strategies for controlling attack via advanced metallic and ceramic coatings. The Turbine Engine Hot Section Technology Project (HOST) augments the life prediction area of our program.

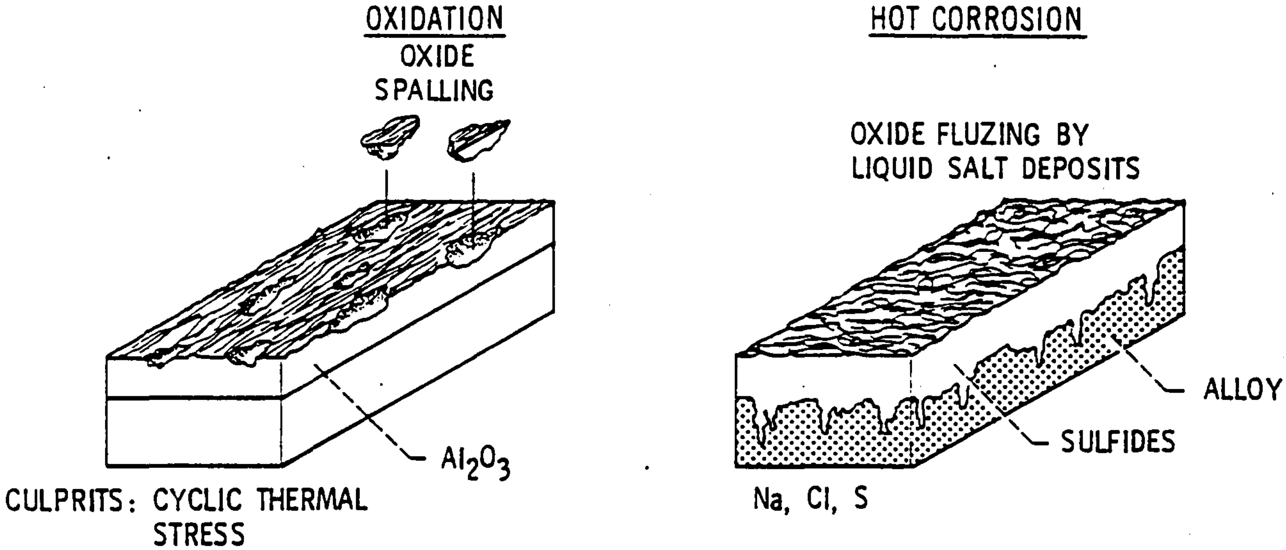
Our objective under HOST is to develop a first-cut integrated environmental attack life prediction methodology for hot section components. Under HOST we are concerned with oxidation and hot corrosion attack of metallic coatings as well as their degradation by interdiffusion with the substrate. The effects of the environment and coatings on creep/fatigue behavior are being addressed through a joint effort with the Fatigue sub-project. Finally, an initial effort will attempt to scope the problem of thermal barrier coating life prediction. Verificiation of models will be carried out through benchmark rig tests including a 4 atm. replaceable blade turbine and a 50 atm. pressurized burner rig.

SURFACE PROTECTION OVERVIEW

S. R. LEVINE
MATERIALS DIVISION
MATERIALS DURABILITY BRANCH



SCHEMATIC OF MODES HIGH-TEMPERATURE ATTACK



SURFACE PROTECTION

OBJECTIVE: DEVELOP AN INTEGRATED ENVIRONMENTAL ATTACK LIFE PREDICTION METHODOLOGY FOR HOT SECTION COMPONENT LIFE

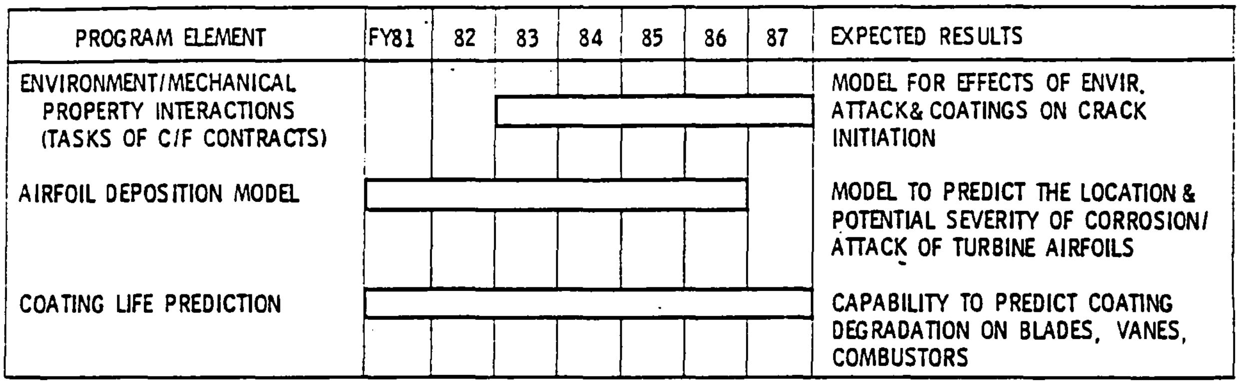
APPROACH:

- COMPILE FIELD FAILURE MODES DATA BASE
- MODEL EFFECTS OF ENVIRONMENTAL ATTACK AND COATINGS ON CRACK INITIATION
- CORROSION/~~EROSION~~ MODEL FOR AIRFOILS
- COATING OXIDATION/DIFFUSION MODEL
- COATING HOT CORROSION LIFE PREDICTION
- THERMAL BARRIER COATINGS
- MODEL VERIFICATION/INTEGRATION

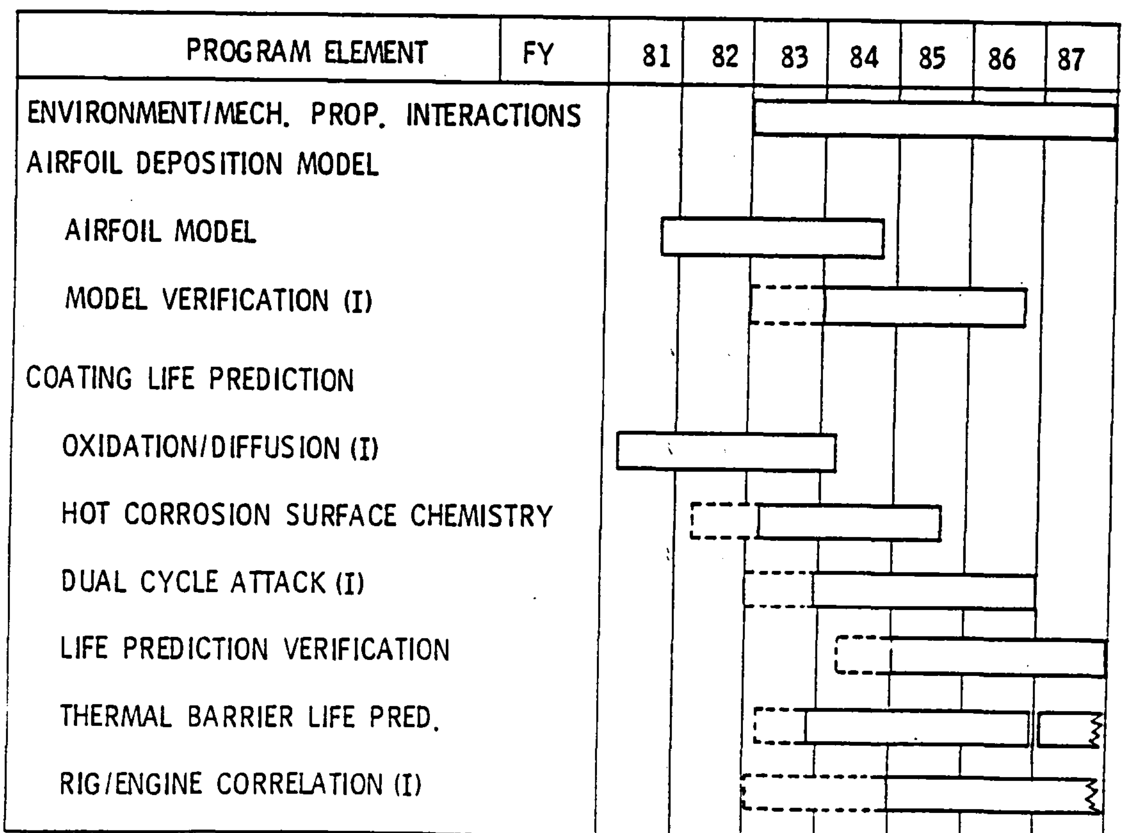
COMMENTS:

- THIS WILL BE A FIRST CUT
- TIME, MANPOWER AND ARE INSUFFICIENT UNDER HOST TO DEVELOP A FULLY SATISFACTORY METHODOLOGY

SURFACE PROTECTION



SURFACE PROTECTION



AIRFOIL DEPOSITION MODEL

GOAL: DEVELOP THEORY TO PREDICT CORRODANT DEPOSITION ON TURBINE AIRFOILS

DURATION: 36 MONTHS

APPROACH:

- GRANT - DAN ROSNER, YALE
- EXTEND CHEMICALLY FROZEN BOUNDARY LAYER THEORY TO AIRFOILS
  - LAMINAR & TURBULENT FLOW
  - PRESSURE & TEMPERATURE OVER AIRFOIL
- MULTI-COMPONENT CORRODANTS

AIRFOIL DEPOSITION MODEL VERIFICATION

GOAL: VERIFY DEPOSITION MODEL AND INTEGRATE WITH ALLOY CORROSION RATE MODEL

DURATION: 48 MONTHS, IN-HOUSE

APPROACH: USING 4 ATM REPLACEABLE BLADE TURBINE RIG

- VERIFY AIRFOIL DEPOSITION MODEL
- VERIFY ALLOY RATE MODEL (FROM R & T BASE)
- INTEGRATE TO LOCATION/RATE MODEL

COATING OXIDATION/DIFFUSION LIFE PREDICTION

GOAL: TO DEVELOP AN IMPROVED METHODOLOGY FOR PREDICTING OXIDATION LIFE OF METALLIC COATINGS

DURATION: 36 MONTHS, IN-HOUSE

APPROACH: SELECT, PROCURE COATED SPECIMENS

DETERMINE COATING LIFE VS TEMPERATURE

FURNACE
BURNER RIG

MEASURE SPALLING PARAMETERS FROM ISOTHERMAL OXIDATION

DETERMINE KINETICS OF DIFFUSIONAL DEGRADATION

DEVELOP CYCLIC OXIDATION MODEL WITH MODIFICATION FOR COATING DIFFUSIONAL DEGRADATION

TEST MODEL BY VARIATION OF CYCLE FREQUENCY

HOT CORROSION SURFACE CHEMISTRY

GOAL: DETERMINE EFFECT OF SURFACE CHEMISTRY ON HOT CORROSION LIFE

DURATION: 36 MONTHS

APPROACH:

- ANALYZE REPRESENTATIVE FIELD COMPONENTS
- DETERMINE COATING LIVES FOR VARIATIONS IN
  - ALLOY
  - COATING
  - COATING AGE
  - AGING METHOD
- MODEL RESULTS/SUGGEST METHODOLOGY FOR LIFE PREDICTION
- VERIFY METHODOLOGY

DUAL CYCLE ATTACK

GOAL: CHARACTERIZE THE EFFECT OF COMBINED OXIDATION/HOT CORROSION CYCLIC EXPOSURE ON LIVES OF METALLIC COATINGS

DURATION: 36 MONTHS (IN-HOUSE)

APPROACH: DETERMINE MACH 0.3 BURNER RIG LIVES FOR COMBINED OXIDATION/ HOT CORROSION CYCLIC EXPOSURE

- VARIATIONS IN DEPOSITION RATE
- VARIATIONS IN TEMPERATURE LEVELS
- VARIATIONS IN COATING AGE

FIT RESULTS TO EMPIRICAL MODEL

LIFE PREDICTION VERIFICATION

OBJECTIVE: VERIFY COATING LIFE PREDICTION METHODOLOGY WITH BURNER RIG BENCHMARK TESTS

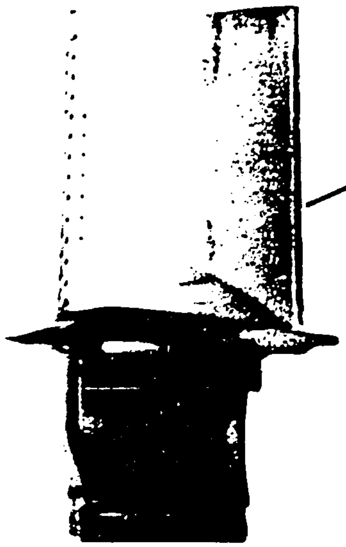
DURATION: 30 MONTHS

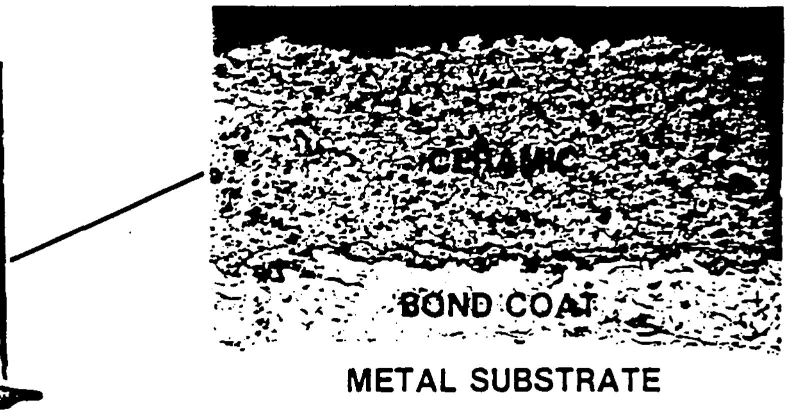
APPROACH: PREDICT COATING LIVES FOR SIMULATED LONG HAUL/SHORT HAUL COASTAL & INLAND MISSIONS

SIMULATE MISSIONS & MEASURE COATING LIFE

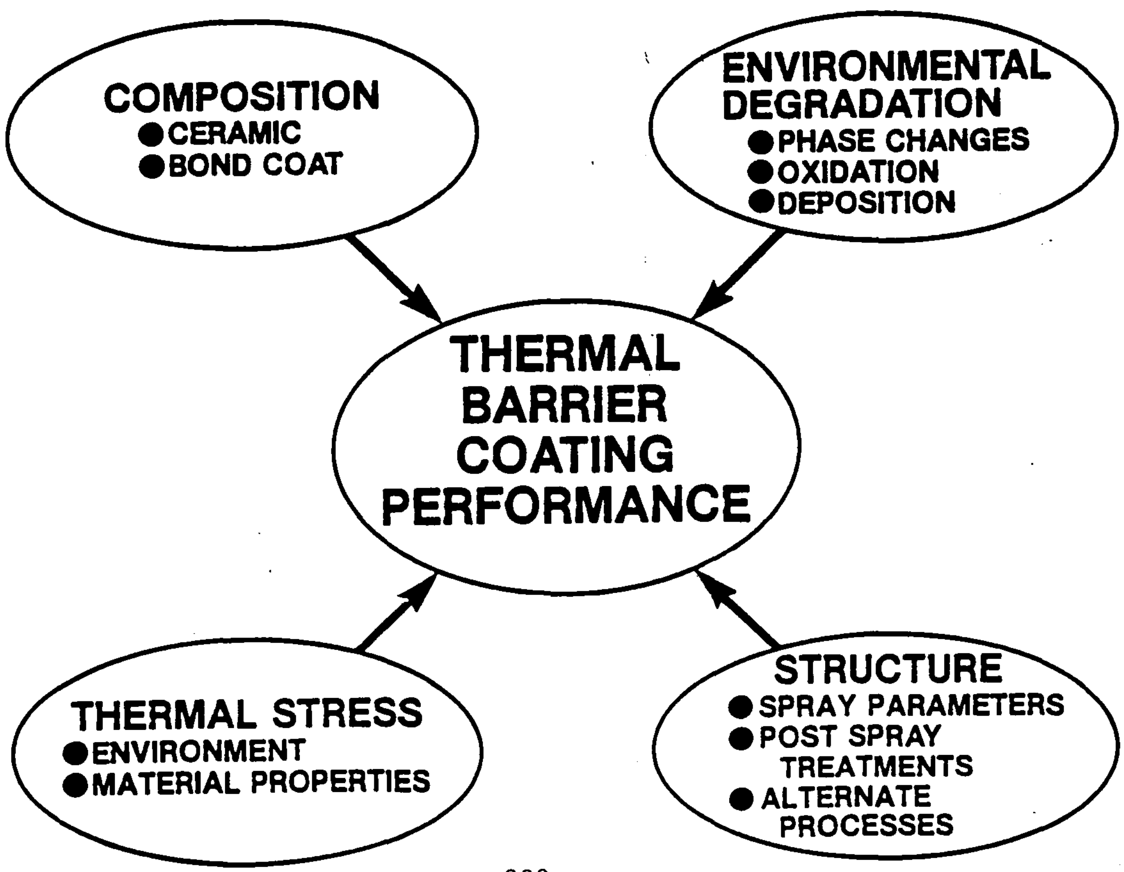
DIAGNOSE PREDICTIVE METHODOLOGY FOR DEFICIENCIES

THERMAL BARRIER COATINGS





- EXTEND LIFE
- INCREASE TEMPERATURE AND/OR
- REDUCE COOLING



TBC LIFE PREDICTION

GOAL: TO DEVELOP AN IMPROVED DESIGN/LIFE PREDICTION METHODOLOGY FOR THERMAL BARRIER COATINGS

DURATION: 36 MONTHS

APPROACH: COMPILE COATING PROPERTY DATA

PREDICT COATING LIFE IN RIG & ENGINE

VARIATIONS IN:

- COATING PROPERTIES
- COATING THICKNESS
- THERMAL CYCLE

TEST PREDICTIVE CAPABILITY BY RIG (& ENGINE) TEST

RIG/ENGINE CORRELATION

GOAL: VERIFY CORROSION, EROSION AND COATING LIFE MODELS AT NEAR ENGINE CONDITIONS

DURATION: 36 MONTHS (IN-HOUSE)

APPROACH: VERIFY MODELS USING HIGH PRESSURE BURNER RIG

- DEPOSITION/CORROSION
- METALLIC COATING LIFE
- THERMAL BARRIER COATING LIFE

DETERMINE MODEL DEFICIENCIES ATTRIBUTABLE TO

- HIGH PRESSURE
- HIGH HEAT FLUX