HOT CORROSION OF LOW COBALT ALLOYS

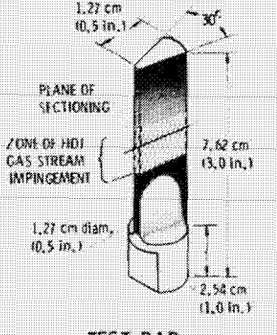
Carl A. Stearns
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio

As part of the COSAM program, we have been investigating the hot corrosion attack susceptibility of various alloys as a function of strategic materials content. Preliminary results have been obtained for two commercial alloys, Udimet 700 and Mar-M 247, that were modified by varying the cobalt content. For both alloys the cobalt content was reduced in steps to zero. Nickel content was increased accordingly to make up for the reduced cobalt but all other constituents were held constant. Wedge bar test samples were produced by casting. The hot corrosion test consisted of cyclically exposing samples to the high velocity flow of combustion products from an air-fuel burner fueled with jet A-1 and seeded with a sodium chloride aqueous solution. The flow velocity was Mach 0.5 and the sodium level was maintained at 0.5 ppm in terms of fuel plus air. The test cycle consisted of holding the test samples at 900° C for 1 hour followed by 3 minutes in which the sample could cool to room temperature in an ambient temperature air stream. Assessing the extent of hot corrosion attack has proved to be a challenge and various methods are being evaluated. Every 15 cycles the sample is placed in a coil and the inductance of the coil plus sample combination is measured. This is a nondestructive method, and results to date indicate that change of inductance can be related to extent of attack and useful life. At the end of 200 cycles samples were electrolytically descaled, weighed, mounted and cross sectioned for metallographic examination to ascertain the extent of attack and amount of unattached alloy remaining. For both alloys tested, hot corrosion attack appeared to decrease as the cobalt content was reduced. Final measurements of the attack have not been completed but the preliminary results indicate that cobalt is deleterious with respect to the hot corrosion attack produced by the test method employed. Further evaluation of the role of cobalt is still in progress.

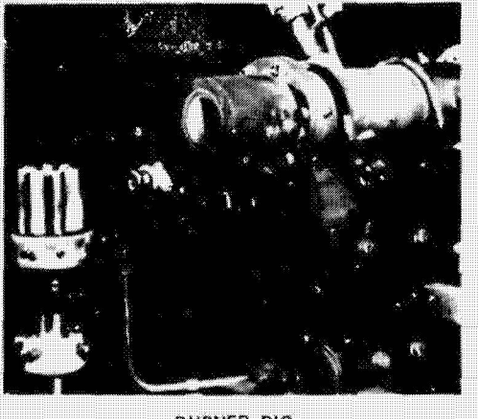
ALLOY CHEMISTRY, IN wt PERCENT, FOR HOT CORROSION TEST SAMPLES

ALLOY	Co	Si	Cr	Ta	Al	Mo	W	Ti	Fe	Hf	Zr	Mn	C
UDIMET 700 - COMMERCIAL	15.5	0.1	14.2	0.0	4.2	4.4	0.0	3.3	0.1	0.0	0.0	0.0	0.1
UDIMET 700 - MODIFICATION 1	17.0	0.1	14.9	0.0	4.1	5.0	0.0	3.6	0.1	0.0	0.0	0.1	0.1
UDIMET 700 - MODIFICATION 2	12.8	0.1	14.7	0.0	4.1	5.0	0.0	3.6	0.1	0.0	0.0	0.1	0.1
UDIMET 700 - MODIFICATION 3	8.6	0.1	15.0	0.0	4.1	5.1	0.0	3.5	0.1	0.0	0.0	0.1	0.1
UDIMET 700 - MODIFICATION 4	4.3	0.1	15.1	0.0	4.1	4.9	0.0	3.6	0.2	0.0	0.0	0.1	0.1
UDIMET 700 - MODIFICATION 5	0.1	0.1	15.1	0.0	4.1	5.0	0.0	3.5	0.1	0.0	0.0	0.1	0.1
Mar M-247 - COMMERCIAL	9.8	0.0	8.4	3.0	5.5	0.7	9.8	1.0	0.1	1.5	0.0	0.0	0.1
Mar M-247 - MODIFICATION 1	5.0	0.0	8.5	3.2	5.4	0.7	10.5	0.9	0.0	1.0	0.1	0.0	0.1
Mar M-247 - MODIFICATION 2	0.1	0.0	8.4	3.9	5.1	0.6	10.2	1.0	0.0	1.0	0.1	0.0	0.1

HOT-CORROSION APPARATUS AND TEST SPECIMEN



TEST BAR



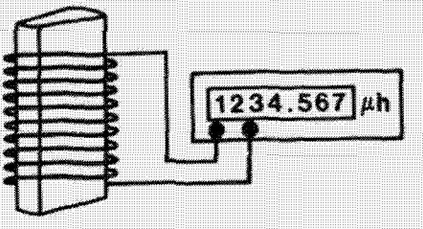
BURNER RIG

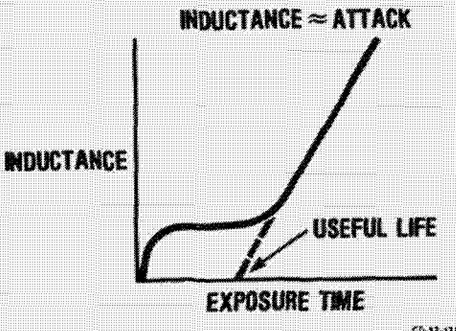
CS-80-1262

NON-DESTRUCTIVE METHOD FOR MEASURING HOT CORROSION OF TURBINE MATERIALS

BURNER RIG OR FURNACE CORROSION EXPOSURE

CORRODED SAMPLE





CO-82-13187

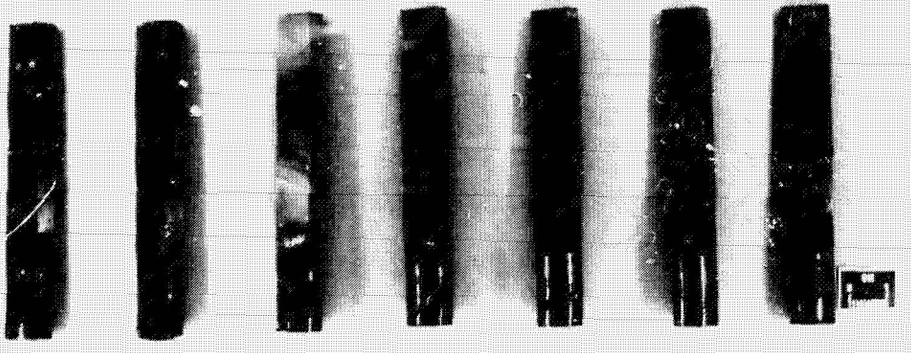
EFFECT OF COBALT ON HOT CORROSION

170 ONE HOUR CYCLES

900 C°

0.5 w PPM Na as NaCl

MACH 0.5



COMMERCIAL U-700
2 VENDORS

0Co

4.3 Co

8.6 Co

12.8 Co

17.0 Co

MODIFIED U-700

CO-82-12950

EFFECT OF COBALT ON HOT CORROSION

170 ONE HOUR CYCLES

900 C°

0.5 w PPM Na as NaCl

MACH 0.5

0Co

5Co

10Co

MODIFIED MAR-M 247

CD-82-12951

COATINGS FOR COSAM ALLOYS

Isidor Zaplatynsky and Stanley R. Levine
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio

A program to investigate the effects of alloy strategic element content on the burner rig oxidation lives of typical high-temperature metallic coatings has been initiated. The first phase of this effo t involves an investigation of the effects of U-700 and Mar-M 247 cobalt-content on the oxidation lives of a typical aluminide coating and a typical low pressure plasma sprayed NiCrAlYSi coating. Early data for the aluminide coated alloys shows an effect of cobalt-content on coating/substrate interdiffusion and on oxidation behavior. The second phase of this effort entails a statistically designed experiment tc study the effects of Cr, Al, Co, Ta, and Mo on coating life. Materials for this effort are being prepared.

COATINGS FOR COSAM ALLOYS

OBJECTIVE: DETERMINE EFFECTS OF ALLOY STRATEGIC METAL CONTENT ON COATING STABILITY AND LIFE

APPROACH:
- DETERMINE EFFECTS OF COBALT/TANTALUM LEVEL IN COSAM ALLOYS (U-700, Mar-M 247, ETC.) ON LIFE OF ALUMINIDE AND OVERLAY COATINGS
- CONDUCT BROADER INVESTIGATION OF ALLOYING EFFECTS (Cr, Co, Ta, Al, Mo) ON COATING LIFE

EFFECTS OF COSAM ALLOY COBALT/TANTALUM LEVEL ON COATING LIFE

ALLOYS

- U-700 - Co LEVEL
  - WROUGHT - 5 LEVELS
  - CAST - 1 LEVEL
  - PM - 2 LEVELS
- MarM-247 - Co LEVEL
  - CAST -3 LEVELS
- TANTALUM - ALLOY TBD

COATINGS

- PLASMA SPRAYED NiCoCrAlYSi
- ALUMINIDE

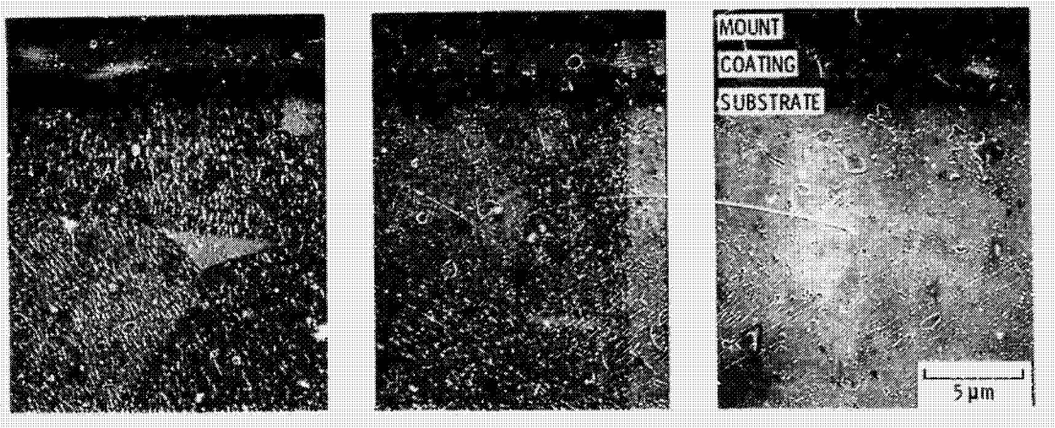
MACH 0.3 BURNER RIG OXIDATION

- ONE TEMPERATURE (1100^0 C)
- 1-hr CYCLES (TIMES TBD)

EFFECTS OF ALLOY COMPOSITION ON COATING LIFE

- BASE ALLOY - U-700 (SAME AS IN HOST)
  VARIABLES - Cr, Al, Co, Ta, Mo
  - STATISTICALLY DESIGNED EXPERIMENT
  CHECKS ON REFRACTORY ELEMENT SUBSTITUTION
  W -- Mo
  Nb -- Ta
- COATINGS
  PLASMA SPRAYED NiCoCrAlYSi
  ALUMINIDE (SAME AS IN HOST)
- EVALUATION
  MACH 0.3 BURNER RIG OXIDATION
  1100^0 C, 1-hr CYCLES, DURATION TBD

EFFECT OF COBALT ON ALUMINIZATION OF U-700



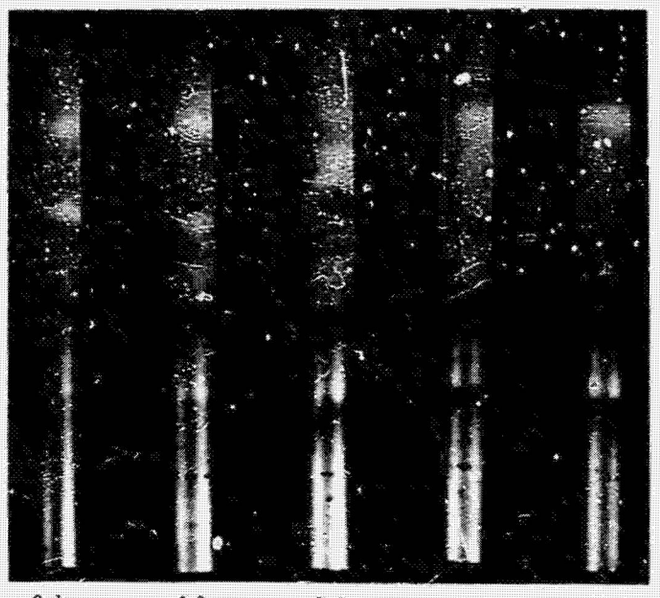
WROUGHT SUBSTRATE COBALT CONTENT, wt%

0.1 | 8.6 | 17.0

CS-82-2247

EFFECT OF COBALT CONTENT ON OXIDATION OF ALUMINIZED U-700

MACH 0.3 BURNER RIG, 150 1-hr CYCLES FRONT FACE: 1100° C



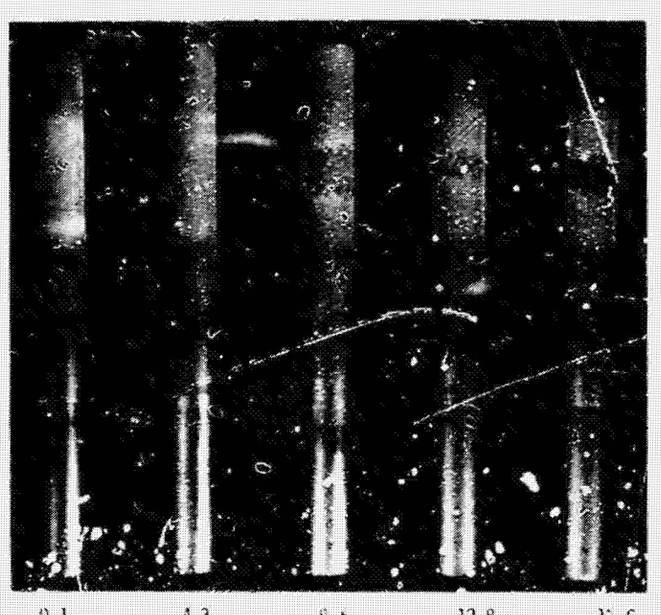
WROUGHT SUBSTRATE COBALT CONTENT, wt%

0.1 4.3 8.6 12.8 17.0

CS-82-2262

EFFECT OF COBALT CONTENT ON OXIDATION OF ALUMINIZED U-700

MACH 0.3 BURNER RIG, 150 1-hr CYCLES BACK FACE: 1120° C



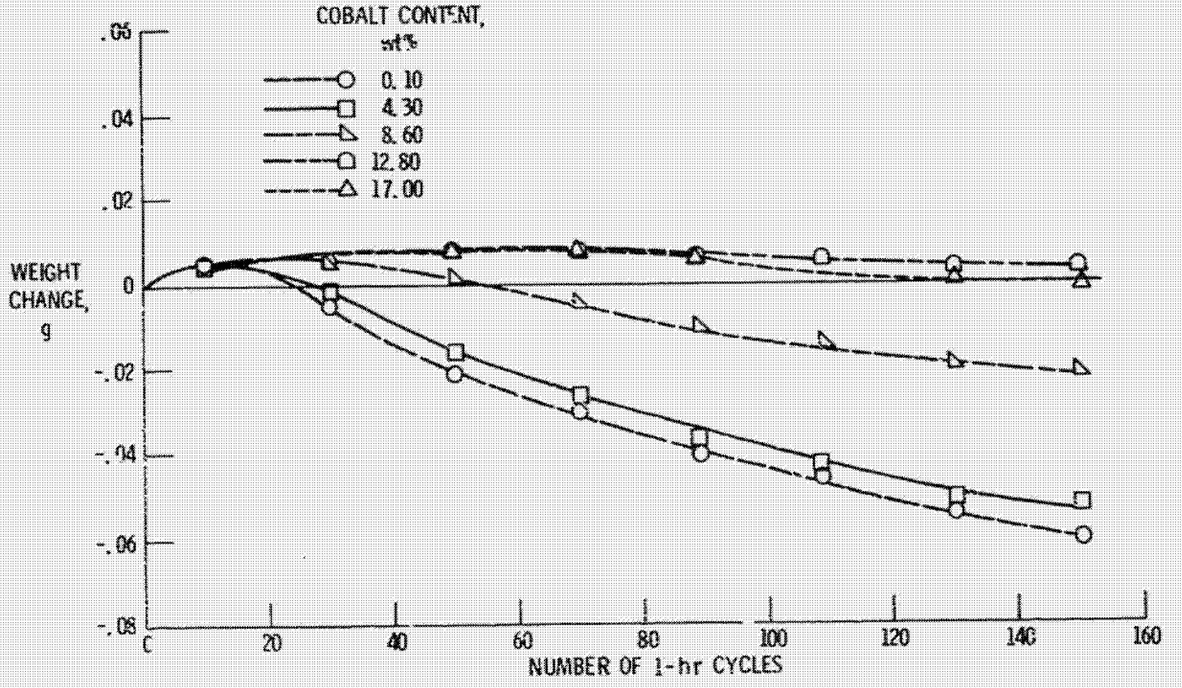
WROUGHT SUBSTRATE COBALT CONTENT, wt%

0.1 4.3 8.6 12.8 17.0

CS-82-2250

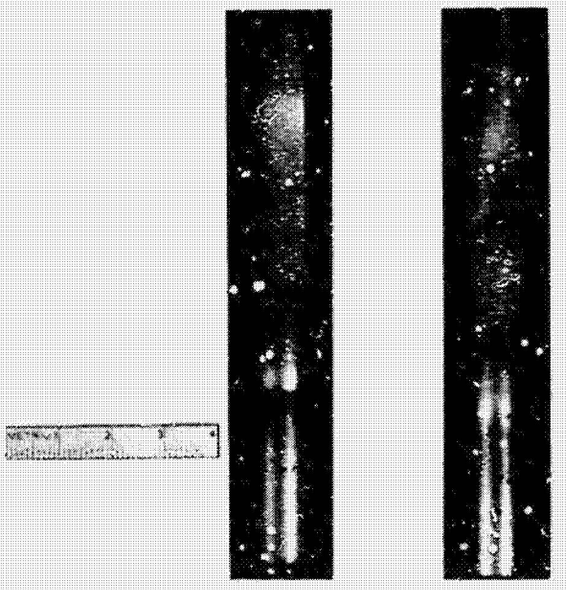
EFFECT OF COBALT ON OXIDATION BEHAVIOR OF ALUMINIZED U-700

MACH 0.3 BURNER RIG, 1100° C (FRONT FACE)



OXIDATION OF ALUMINIDE ON WROUGHT AND CAST U-700 ALLOYS

MACH 0.3 BURNER RIG, 150 1-hr CYCLES FRONT FACE: 1100° C

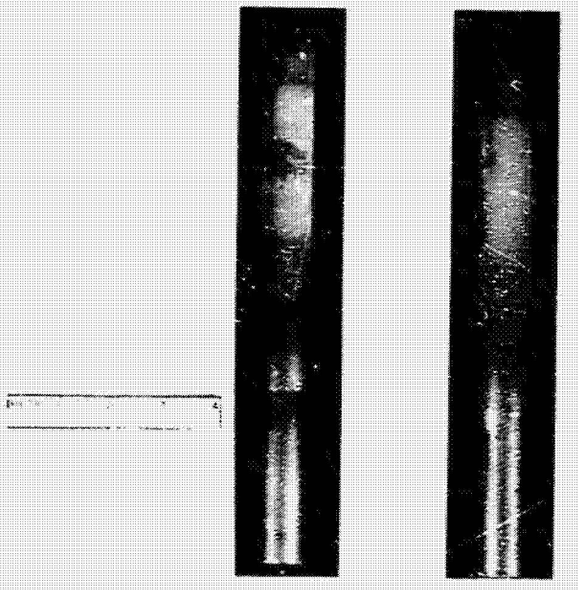


SUBSTRATE	WROUGHT	CAST
COBALT CONTENT, wt%	17.0	19.0

CS-82-2263

OXIDATION OF ALUMINIDE ON WROUGHT AND CAST U-700 ALLOYS

MACH 0.3 BURNER RIG, 150 1-hr CYCLES BACK FACE: 1120° C

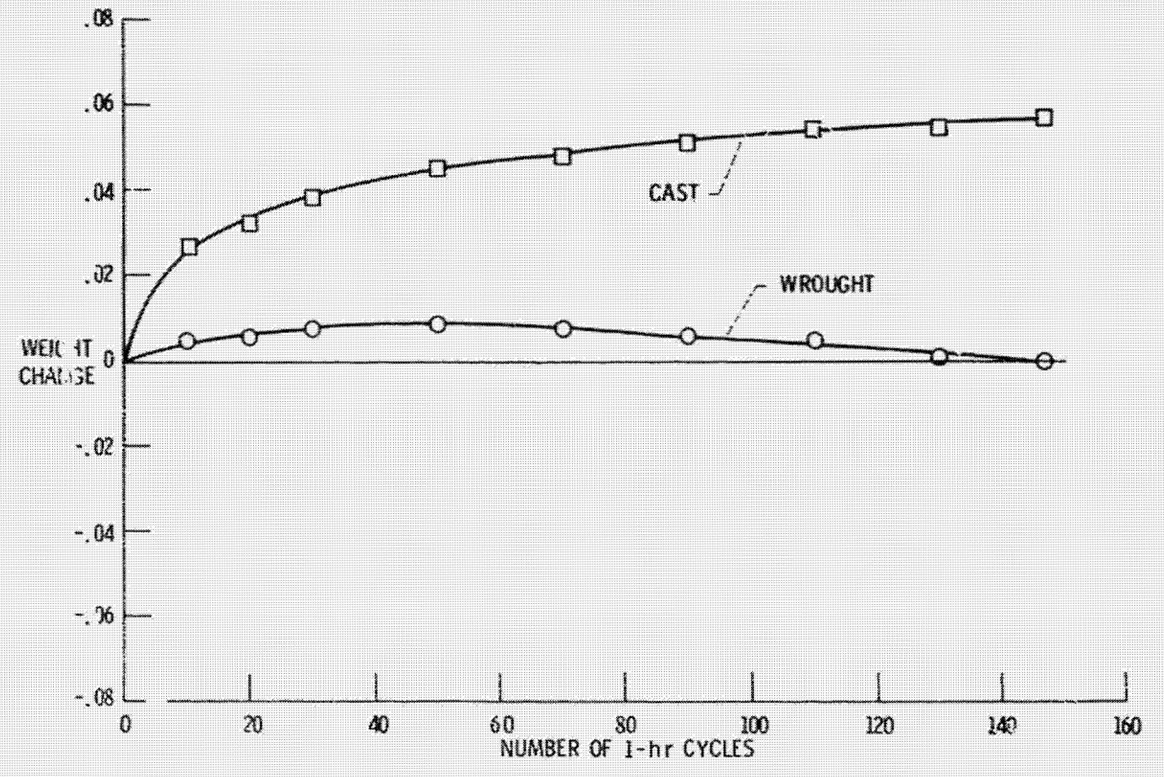


SUBSTRATE	WROUGHT	CAST
COBALT CONTENT, wt%	17.0	19.0

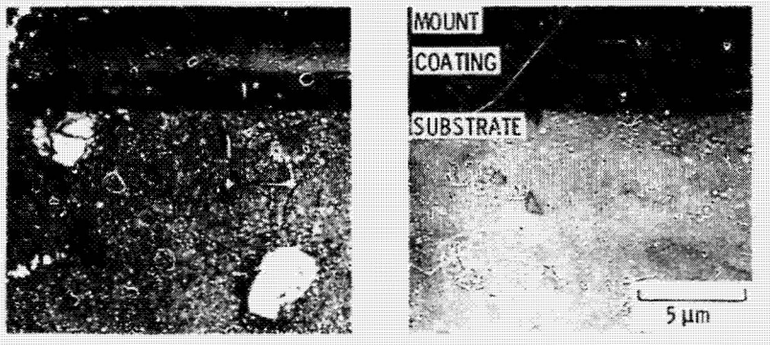
CS-82-2249

OXIDATION BEHAVIOR OF ALUMINIZED U-700 - 18 wt% COBALT

MACH 0.3 BURNER RIG, 1100° C (FRONT FACE)



EFFECT OF Co ON ALUMINIZATION OF MarM-247



SUBSTRATE COBALT CONTENT, wt%

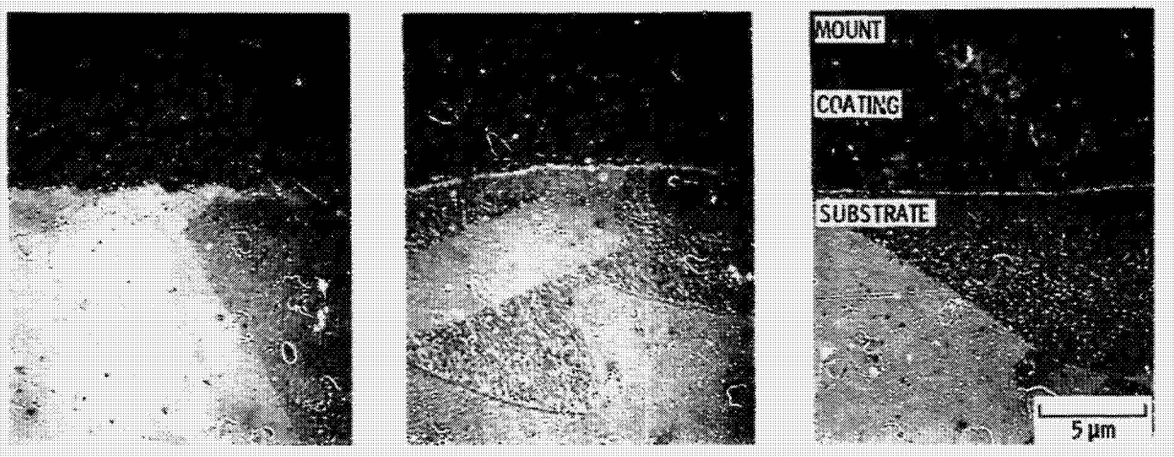
0.1

9.8

CS-82-2245

EFFECTS OF U-700 COBALT ON STRUCTURE OF HT NiCrAlYSi

4 hr, 1080° C, ARGON



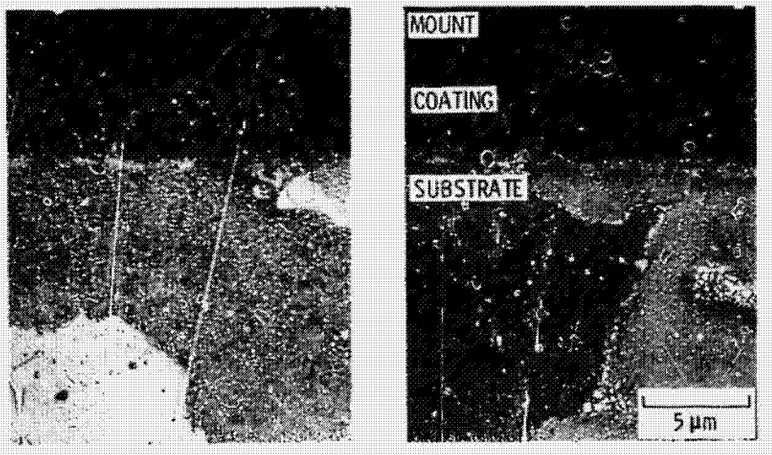
SUBSTRATE COBALT CONTENT, wt%

0.1 | 8.6 | 17.0

CS-82-2248

EFFECTS OF MarM 247 COBALT ON STRUCTURE OF HT NiCrAlYSi

4 hr, 1080° C, ARGON



SUBSTRATE COBALT CONTENT, wt%

0.1 | 9.8

CS-82-2246