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ADVANCED THERMAL BARRIER COATING SYSTEMS

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Current state-of-the-art thermal barrier coating (TBC) systems consist of partially stabilized zirconia coatings plasma sprayed over a MCrAlY bond coat. Although these systems have excellent thermal shock properties, they have shown themselves to be deficient for a number of several diesel and aircraft applications.

Two new ternary ceramic plasma coatings are discussed with respect to their possible use in TBC systems. Zirconia-ceria-yttria (ZCY) coatings have been developed with low thermal conductivities, good thermal shock resistance and improved resistance to vanadium containing environments, when compared to the baseline yttria stabilized zirconia (YSZ) coatings. In addition, dense zirconia-titania-yttira (ZTY) coatings have been developed with particle erosion resistance exceeding conventional stabilized zirconia coatings.

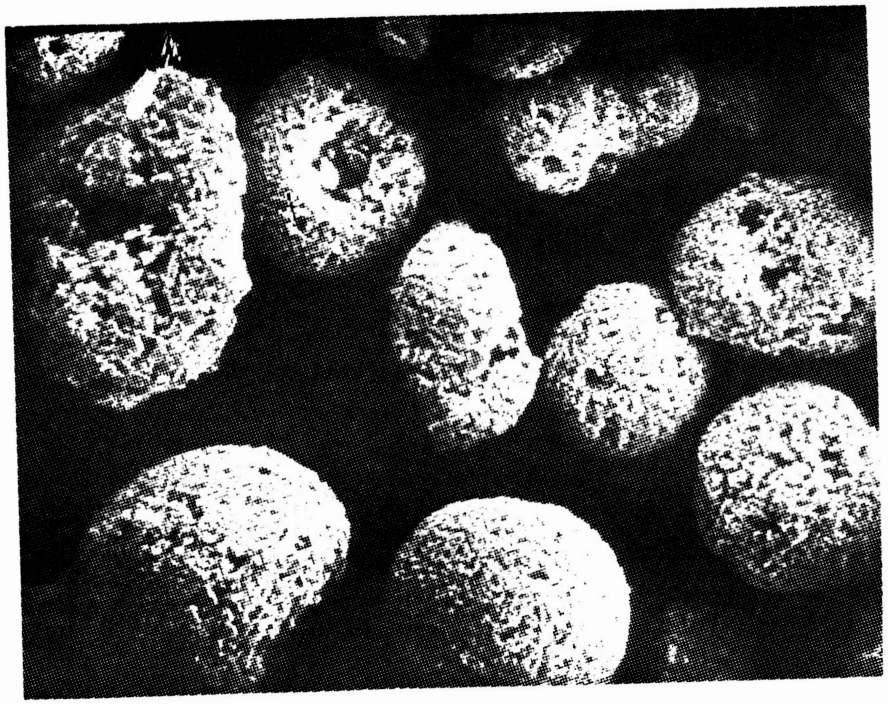
Both coatings have been evaluated in conjunction with a NiCr-Al-Co-Y_2O_3 bond coat. Also, multilayer or hybrid coatings consisting of the bond coat with subsequent coatings of zirconia-ceria-yttria and zirconia-titania-yttria have been evaluated. These coatings combine the enhanced performance characteristics of ZCY with the improved erosion resistance of ZTY coatings.

Improvement in the erosion resistance of the TBC system should result in a more consistent ΔT gradient during service. Economically, this may also translate into increased component life simply because the coating lasts longer.

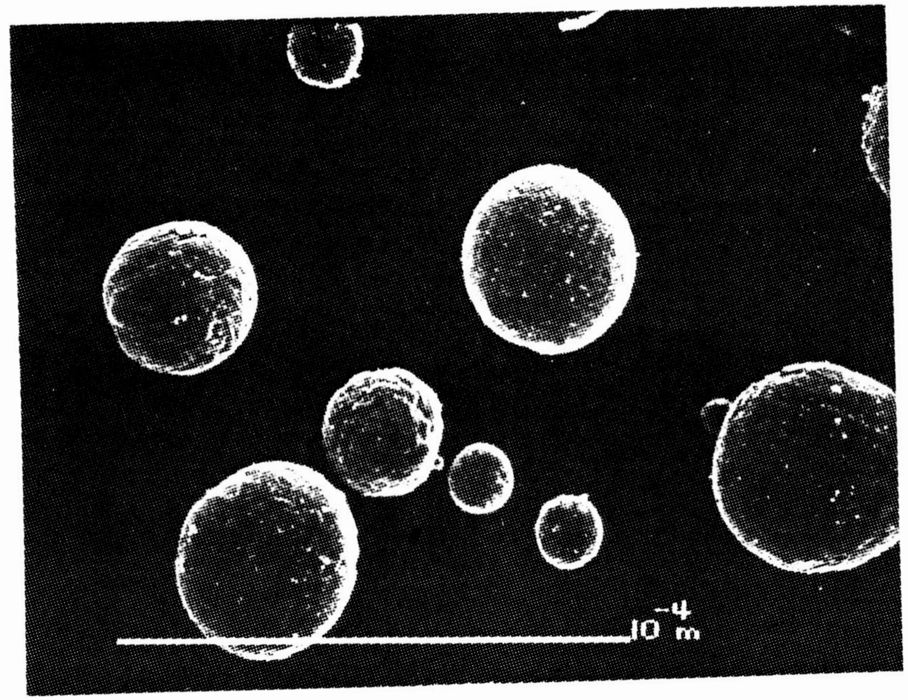
TABLE I. - HOT PARTICLE EROSION

VOLUME OF COATING LOSS (CM^3 X 10^4) PER GRAM OF ABRASIVE

IMPINGEMENT ANGLE	YTTRIA STABILIZED ZIRCONIA #1	YTTRIA STABILIZED ZIRCONIA #2	CERIA STABILIZED ZIRCONIA #3	CERIA STABILIZED ZIRCONIA #4	ZIRCONIA TITANIA YTTRIA #5
30^0	1.45	1.35	1.43	2.06	0.29
60^0	1.55	2.12	2.05	4.64	0.83



TYPICAL SPRAY DRIED
COMPOSITE POWDER

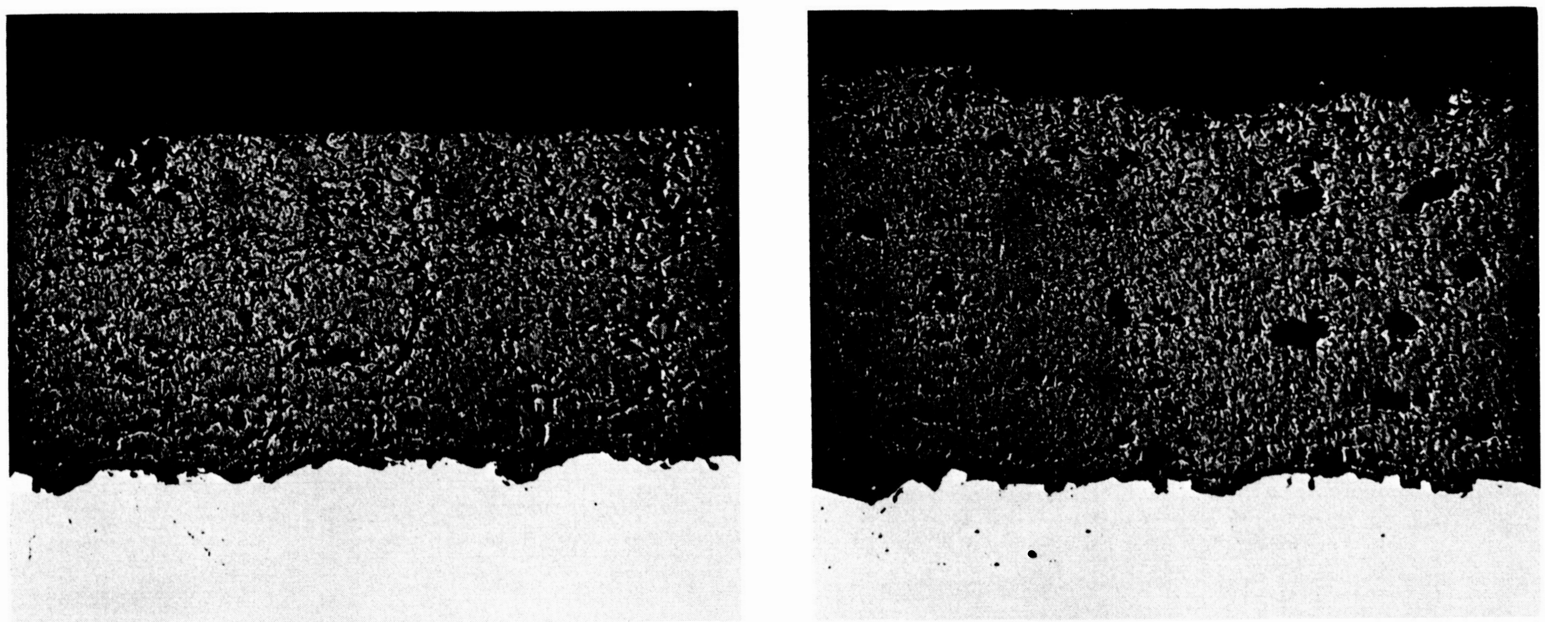


TYPICAL PRE-STABILIZED
SPHERICAL POWDER

Figure 1. - SEM photomicrographs (x700).

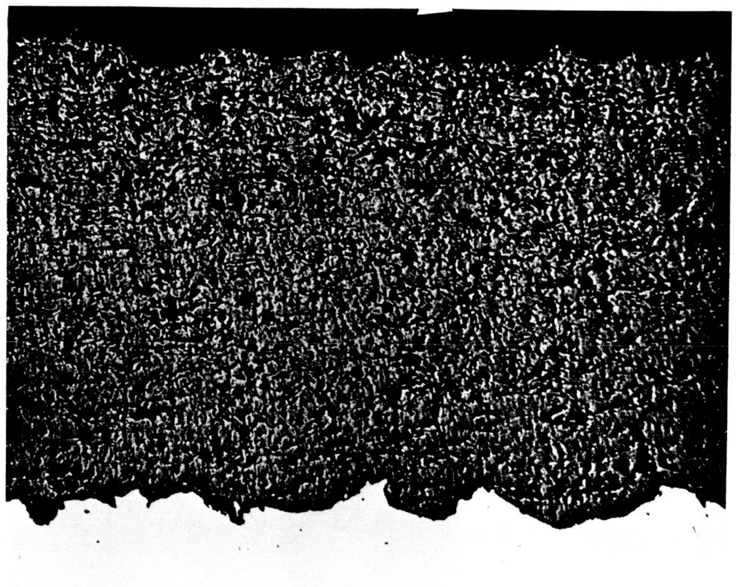
TABLE II. - SPRAY PARAMETERS

	YTTRIA STABILIZED ZIRCONIA		CERIA STABILIZED ZIRCONIA		ZIRCONIA TITANIA YTTRIA COMPOSITE
PLASMA GUN	9MB		9MB		9MB
NOZZLE	732		732	730	731
POWDER PORT	#2		#2	#2	#2
GAS TYPE	ARGON/HYDROGEN		AR/H_2	$N2/H_2$	ARGON/HYDROGEN
SPRAY DISTANCE (MM)	65	100	100	100	76
SPRAY RATE (GMS/MIN)	45.4	45.4	45.4	45.4	37.8
PRESSURE:					
PRIMARY	100	75	75	50	100
SECONDARY	50	50	50	50	50
FLOW:					
PRIMARY	80	80	80	75	75
SECONDARY	15	15	15	15	15
CURRENT	600	600	600	500	600
VOLTAGE	70	70	70	80	70
COATING	1	2	3	4	5

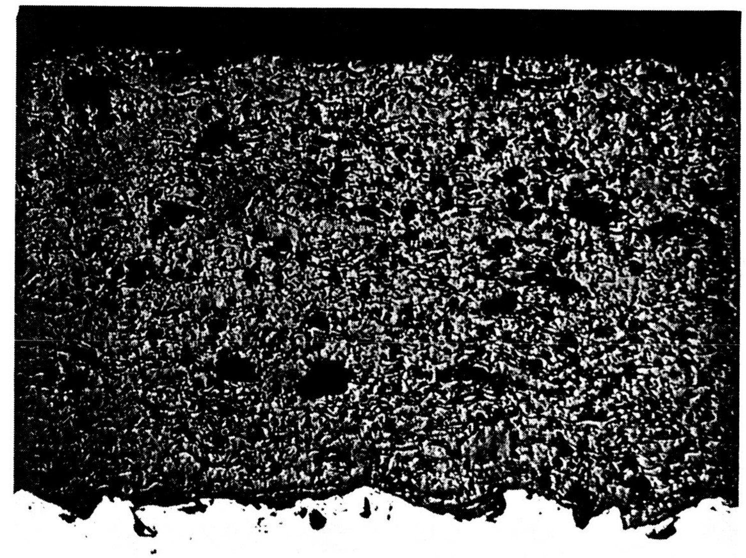


COATING #1 COATING #2

Figure 2. - Yttria stabilized zirconia coating microstructures (x100).



COATING #3



COATING #4

Figure 3. - Ceria stabilized zirconia coating microstructures (x100).

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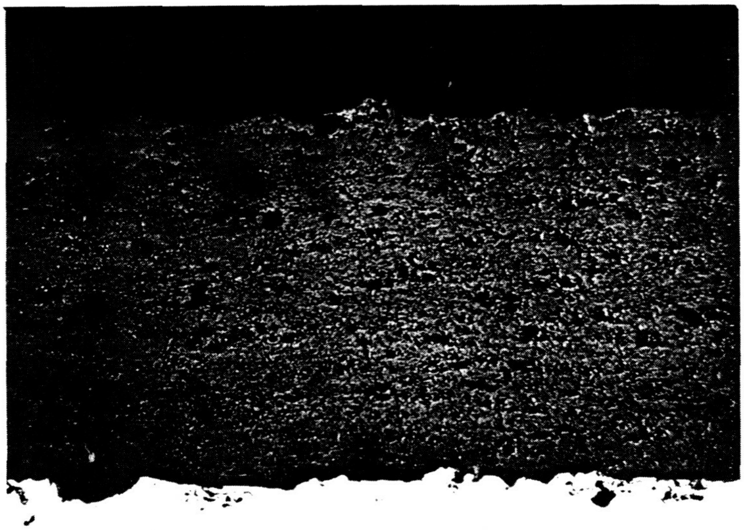
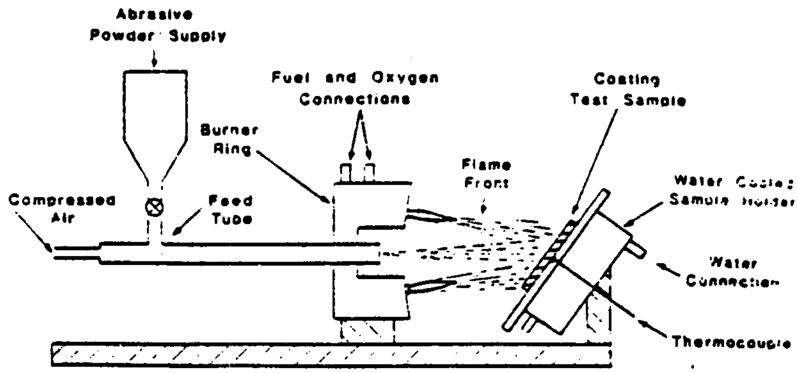


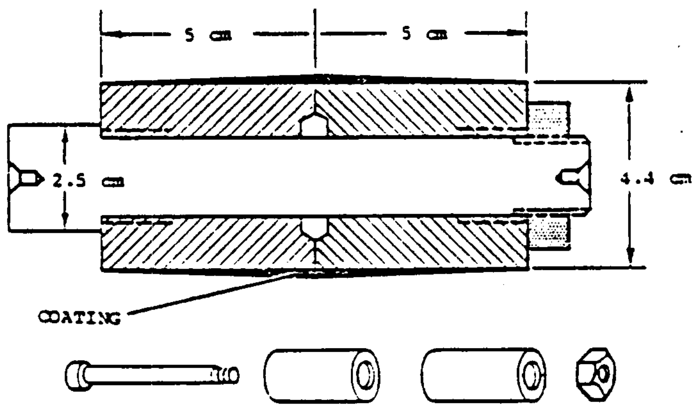
COATING #5

Figure 4. - Zirconia, titania, yttria coating microstructure (x100).

*HIGH TEMPERATURE PARTICLE EROSION



*COHESIVE STRENGTH



*CYCLIC THERMAL SHOCK

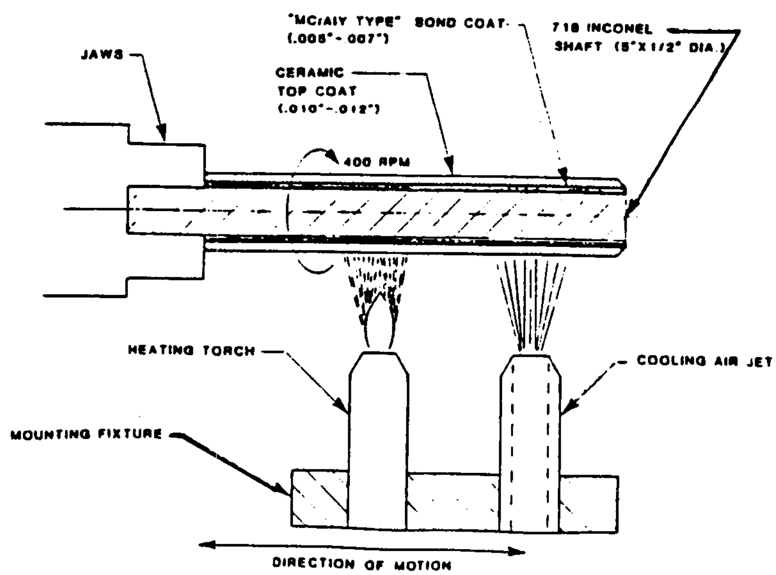


Figure 5. - Experimental test procedure.

TABLE III. - POWDER CHARACTERISTICS

	YTTRIA STABILIZED ZIRCONIA	CERIA STABILIZED ZIRCONIA WITH YTTRIA	ZIRCONIA-TITANIA-YTTRIA COMP. POWDER
NOMINAL CHEMISTRY (WT%)	ZIRCONIA BASE	ZIRCONIA BASE	ZIRCONIA BASE
	YTTRIA - 8%	CERIA - 26%	TITANIA - 18%
		YTTRIA - 2.5%	YTTRIA - 10%
POWDER SIZE	-120 MESH +10 MICRONS	-170 MESH +10 MICRONS	-200 MESH +10 MICRONS
POWDER MORPHOLOGY	PRE-STABILIZED SPHERICAL POWDER	PRE-STABILIZED SPHERICAL POWDER	SPHERICAL SPRAY DRIED COMPOSITE