

Sea water Corrosion of Nickel based Plasma Spray Coating

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Abstract

Different types of erosion resistant coatings are applied/deposited on aero components, depending on the operating/working temperatures. Nickel based coating are applied on the air craft (compressor) components, which can sustain up to working temperature of 650°C. In the present investigation, to improve the compatibility between substrate (i.e. the machine component) and the top coat, application of bond coat is there. The application of Nickel based coating by thermal plasma spray technique has proven to be a satisfactory means of producing acceptable sealing surface with excellent abrasability. Before the corrosion study, coated sample is subjected to hardness, thickness and porosity testing. Hence the result is being evaluated. The corrosion behavior of coating was studied by sea water immersion with a time period of 16 weeks. It is observed that, up to 9 weeks increase in weight of coating occurs in a sharp trend and then takes a decreasing trend. The weight gain of the samples has varied from 37.23% (with one week immersion in sea water) to a maximum of about 64.36% for six weeks immersion. Coating morphology and composition analysis of the coatings are studied using SEM and EDS. This behavior shows adsorption/deposition of the foreign particles with polygonal shape on the coating surface by sea water interaction. Foreign particles with polygonal shape deposited on the coating and with increase in immersion/treatment time, washing out of the deposited materials starts, which reflects the decreasing trend of weight gain of the specimen.

Key words: thermal plasma, erosion resistant coating, nickel base coating, plasma spraying, sea water corrosion.

1. Introduction

Thermal plasma spray coating is one of the effectively developed modern technology to resist the surface from degradation. Coating made with plasma technique exhibit excellent wear, corrosion and thermal resistance. Nickel based abrasable coating is used with thermal plasma spray techniques in air craft (Compressor components), which can sustain up to working temperature of 650°C, by improving engine efficiency. Characteristics of coating varies due to substrate surface preparation and critical plasma spray parameters [1-4]. Spraying condition like CPSP affects the final coating microstructure, hardness, porosity and adhesion strength etc. Hence selected CPSP is taken for better coating result. Plasma spray coating is composed of layers that are formed when molten liquid



droplets flatten and solidify on the surface [5-7]. Till date, no effort has been taken on the characterization and evaluation of sea water corrosion behavior of different plasma spray coating used in aero engines. Present piece of work is intended to study corrosion behavior of Nickel base plasma spray coating, when treated with sea water at different time length.

2. Experimental

2.1. Substrate Preparation

Nimonic plates were used for substrate surface (as this is been used in aero-components). Substrate surface was roughened using Al_2O_3 powder of grit size 60 to produce a surface roughness of 4-6 micron Ra.[8]. The roughened surface was protected from contaminations up to spraying to avoid disintegration of coating.

2.2. Preparation of coating powder

Powders of Nickel, Copper Oxide, Cadmium Oxide and Hexagonal Boron Nitride powder are sieved, after baking at $130^\circ - 150^\circ \text{C}$ for 2-3 hr. Nickel powder 54- 68 %, Copper Oxide 10 -12%, Cadmium Oxide 3-5%, Boron Nitride 16-19%, Graphite 1-4 % and Aluminium Powder were mixed in a ball mill along with liquid glass. The mixture is rubbed over sieve and baked at 150°C and finally sieved to get the final before use..

2.3. Spray Deposition

Plasma spraying condition i.e. CPSP parameters were selected carefully for coating, where Argon (53 lpm) is used as Primary plasma Gas & Hydrogen (4 lpm) is used as Secondary Plasma- gas with Current(460 Amp).After coating the samples were heat treated at 650°C for half an hour.

2.4. Specimen preparation for corrosion test

With the help of EDM wire cut the coating specimens were cut into slices of 3-4 mm thickness and 3-6 gm weight. The cut samples were treated with sea water (Bay of Bengal) to study the corrosion behavior at different time length. The chemical composition was analyzed before corrosion test, is tabled below.

Table 1. Composition of Bay of Bengal sea water.

Type of ion	Element	Concentration (Mg/ltr)	% by wt.
Cation	K^{+1}	380	1.10
	Na^{+1}	10500	30.42
	Sr^{+2}	8	0.02
	Mg^{+2}	1350	3.91
	Ca^{+2}	400	1.16
Anion	F^{-1}	1	0.003
	Cl^{-1}	19000	55.04
	SiO_3^{-2}	8	0.02
	SO_4^{-2}	2655	7.04
	BO_3^{-3}	20	0.06
	CO_3^{-2}	140	0.41
	Br^{-1}	65	0.19

3. Results and discussion

3.1. Hardness test

Coated sample surfaces were polished using emery paper of distinctive grit size for hardness estimation. Brinell hardness test was performed at room temperature on 10 different areas and to get the average hardness value, and were observed to be in the range of 7-13 HB.

3.2. Corrosion Test

Corrosion behavior of coating was studied by sea water immersion with a time period of 16 weeks. Weight of specimens were taken before and after treatment at different time interval and the results are tabled below.

Table 2. % change in weight with time.

Sl No.	Time in weeks	Initial Weight (gm)	Final Weight (gm)	Change in weight (gm)	% change
1	16	5.01	6.88	1.87	37.33
2	15	4.04	5.88	1.84	45.54
3	14	5.48	7.52	2.04	37.23
4	12	4.02	5.95	1.93	48.01
5	11	3.04	4.86	1.82	59.87
6	9	3.03	4.98	1.95	64.36
7	8	4.7	6.68	1.98	42.13
8	7	4.62	6.72	2.1	45.45

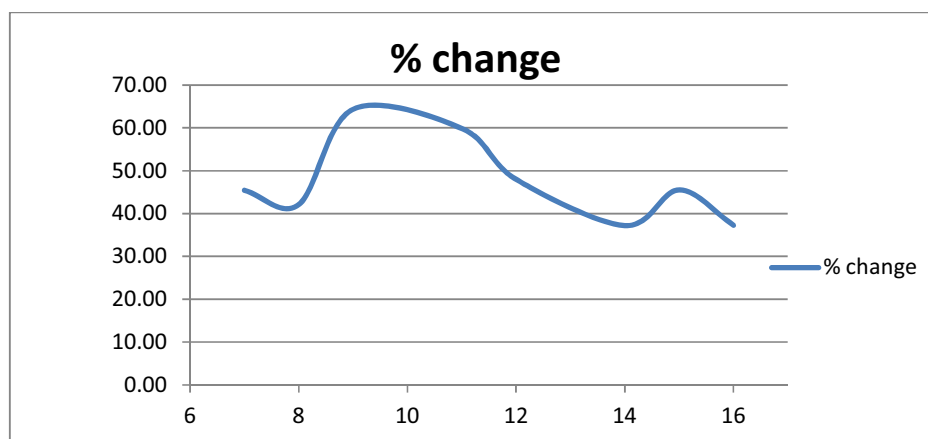


Figure 1. Time Vs wt. change

The graph shown in Fig. 1 shows that deposition of the foreign elements taking place on coating surface occurs during sea water interaction and with increase in immersion/treatment time, washing out of the deposited materials starts, which reflects the decreasing trend of weight gain of the specimen.

3.3. Coating Morphology

SEM micrograph and EDS analysis of raw & corroded samples, in Fig. 2 and Fig. 3.

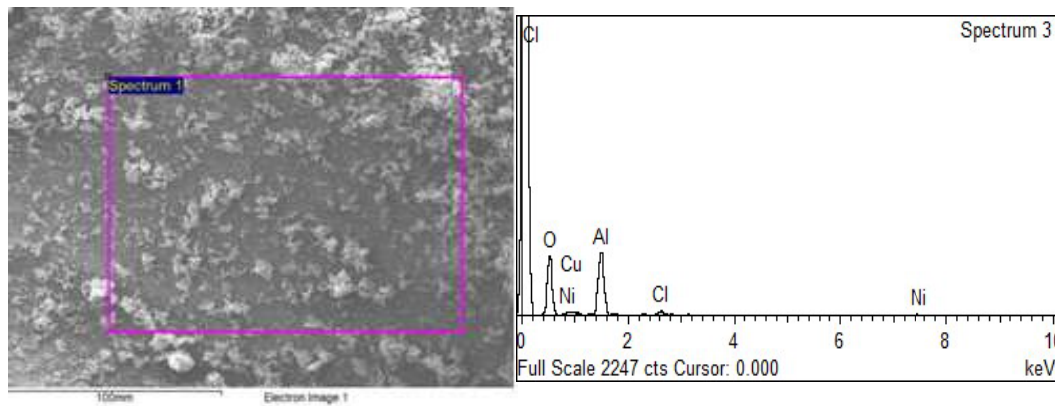


Figure 2. Untreated specimen EDS and SEM spectra.

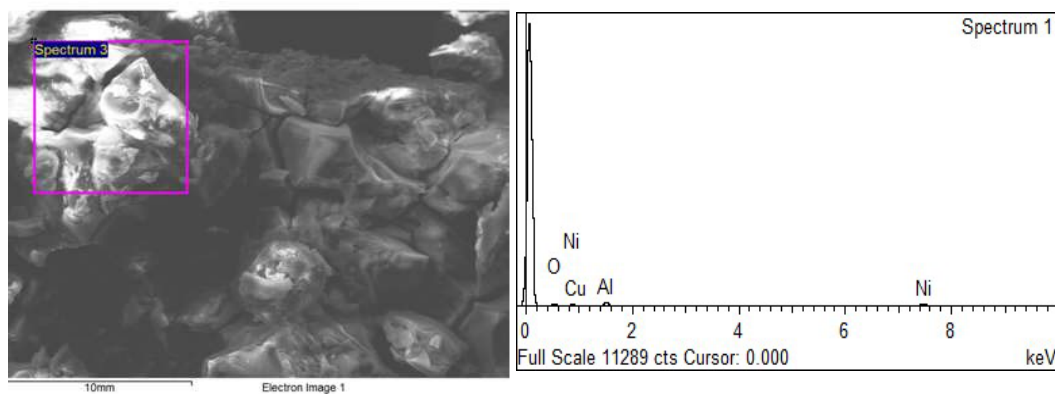


Figure 3. Treated specimen EDS and SEM spectra.

SEM micrograph of coating deposited at CPSP by plasma spray in Fig. 2 and Fig. 3, show uniform distribution of molten /semi molten particles. Coating deposited are smooth, more homogenous, having least porosity with the selected CPSP parameters. This might be the reason to get a suitable dense coating. SEM morphology of corroded sample in Fig. 3 shows small foreign particles with polygonal shape deposited on the coatings. EDS analysis data of corroded sample from Table 3 and Table 4 showed the increase in oxygen in large amount where as very less increase in Cl is there. Which implies, some kind of ionic reactions are taking place. Further detailed examination is in progress. The polygonal shaped particles are deposited on coating surface and EDS analysis exhibit the increase/presence of Cl, which is also another clue to confirm the formation of some chlorine compound; as the cation (Cl) concentration is more in sea water than the anion concentration.

Table 3. Coating elemental analysis before treated by EDS .

Element	Weight%	Atomic%
Al K	15.98	16.66
Si K	2.20	2.20
Ti K	4.80	2.82
Ni K	35.86	17.18
O K	32.62	57.35
Cu K	8.53	3.78
Totals	100.00	

Table 4. Elemental analysis of the coating after dipped in sea water for 10 weeks by EDS .

Element	Weight%	Atomic%
Al K	26.41	18.84
Cl K	2.38	1.29
O K	64.71	77.84
Ni K	2.76	0.91
Cu K	3.74	1.13
Totals	100.00	

4. Conclusions

From this investigation it is found that, the Ni base abradable coatings used in aero component could be plasma sprayed with thermal plasma spray technique. The coating hardness is found to be 7-13HB. There is a weight gain of the coatings with initial time period of deeping in sea water but after few weeks there is a decrease in weight; may be due to washing out of compounds formed with interaction of the coating with sea water with prolonged time of treatment; implies weakening of the coating materials. From the SEM and EDS observations, the formation of polygonal shaped particles on the coating surface and increase in Cl component implies and confirms the formation of other compounds with sea water.

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