IMPROVING EROSION RESISTANCE ON SS 431 USING DETONATION SPRAY COATINGS EMPLOYED IN SLURRY ENVIRONMENTS

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ABSTRACT

Thermally sprayed hard metal coatings are used in several industrial applications. The working parts are subjected to corrosive environments in these applications. Engineered coatings are used in these conditions to increase the life of these parts that undergoes erosive wear due to the action of abrasive slurry. Alumina and Alumina-Titanium coatings were coated onto stainless steel substrates by Detonation Spraying. The erosion behaviour of the coatings were studied against quartz mixed slurry counter bodies at 3 different speeds (500rpm, 750rpm & 900 rpm) and at 5 different time intervals (4hours, 7hours, 12hours, 20hours & 25hours) in a pot erosion tester. The Mass loss and Erosionwear rateof the specimens were determined. The morphology and properties of the eroded specimens were studied by SEM. The elemental analysis was done by EDAX. Scratch test, Wear test, Micro hardness was also determined and the results of both the coated specimens were compared.

Key words: Detonation spraying, Alumina, Alumina-Titanium coatings, Mass loss, Erosion wear rate.

INTRODUCTION

Erosion is defined as progressive loss of original material from a solid surface due to mechanical interaction between that surface and a fluid, a multicomponent fluid, or impinging liquid or solid particles.Solid particles entrained in liquid stream are referred to as slurry erosion. Hydraulic machinery and equipments such as turbines, pumps, valves etc. are normally subjected to slurry erosion.Stainless steel is used where both the properties of steel and resistance to corrosion are required. But despite the name it is not fully stain-proof, most notably under low oxygen, high salinity, or poor circulation environments. To overcome these problems engineered coatings like Alumina and Aluminium-Titanium are used. Detonation gun spraying is used to deposit the coatings on the SS431 substrate.

The slurry erosion phenomenon in stainless steel (SS316L/UNS S31603), carbon steel (AISI 1020/UNS G10200) and nickel-aluminium bronze (NAB/UNS C63200) was studied by Harvey et al(2006).A slurry pot erosion tester was used as the test apparatus and test parameters such as erodent size, erodent concentration, flow velocity and test solutions were varied to study their effect on erosion. SEM analysis showed that a similar erosion mechanism is seen for SS316L and NAB with formation of multiple extruded lips and platelets typically seen for erosion dominated material.

EXPERIMENTAL DETAILS

Stainless steel 431 specimens are machined for a dia of 15mm and thickness of 10mm. The required number of specimens is now coated with Alumina and Aluminium-Titanium coatings. Only one particular surface of the specimen is coated. Detonation spraying is used to coat the specimens. The coating thickness is about 425microns on average. Fig 1a and 1b shows the Alumina and Aluminium-Titanium coatings respectively

Fig 1a Alumina

Fig 1b Aluminium-Titanium

A slurry pot erosion tester is used to determine the erosion wear rate and mass loss of the specimen. Slurry pot erosion tester is a simple and inexpensive test rig which can provide a rapid ranking of the erosion resistance for different materials. The slurry is prepared by mixing water and quartz in the ratio of 90:10, 80:20, and 70:30 concentrations. The quartz particle size used here is 60-80 micron mesh. The slurry mixture is changed periodically (every 7 hours) to ensure that it does not lose its abrasive property.

The mass loss and erosion wear rate of the coatings for specific time intervals of 4hrs, 7hrs, 12hrs, 20hrs and 25hrs and varying speeds of 500rpm, 750rpm and 900rpm is determined. The speed at which the mass loss is maximum is targeted and further testing is done in various concentrations to determine the effect of concentration and time. Fig 3a and 3b shows a pot erosion tester with the control unit.

Fig 3a Pot erosion tester

Fig 3b Control unit

RESULTS AND DISCUSSIONS

(I)Concentration- 80:20% 500 rpm:

Time	Alumina		Aluminum-Titanium	
	Mass loss (g)	Erosion wear rate (mg/km) *10^-5	Mass loss (g)	Erosion wear rate (mg/km) *10^-5
4 hours	0.0007	1.1392	0.0005	0.8137
7 hours	0.0017	2.7667	0.0011	1.7902
12 hours	0.0034	5.5334	0.0022	3.5804
20 hours	0.0047	7.6491	0.0032	5.2079
25 hours	0.0058	9.4393	0.0041	6.6726

750 rpm:

Time	Alumina		Aluminum-Titanium	
	Mass loss (g)	Erosion wear rate (mg/km) *10^-5	Mass loss (g)	Erosion wear rate (mg/km) *10^-5
4 hours	0.0018	2.9294	0.0006	0.9764
7 hours	0.0023	3.7431	0.0015	2.4412
12 hours	0.0037	6.0216	0.0028	4.5569
20 hours	0.0049	7.9746	0.0038	6.1844
25 hours	0.0061	9.9276	0.0047	7.6491

900 rpm:

Time	Alumina		Aluminum-Titanium	
	Mass loss (g)	Erosion wear rate (mg/km) *10^-5	Mass loss (g)	Erosion wear rate (mg/km) *10^-5
4 hours	0.0012	1.9529	0.0005	0.8137
7 hours	0.0021	3.4177	0.0012	1.9529
12 hours	0.0034	5.5334	0.0023	3.7431
20 hours	0.0044	7.1608	0.0036	5.8589
25 hours	0.0060	9.7648	0.0045	7.3236

(II)Concentration- 90:10%:750 rpm:

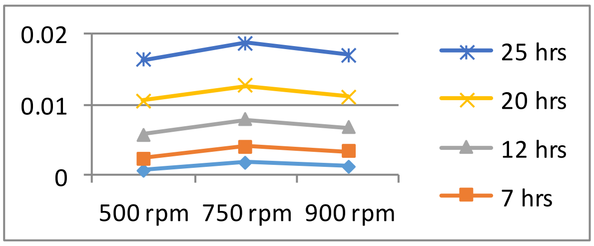
Time	Alumina		Aluminum-Titanium	
	Mass loss (g)	Erosion wear rate (mg/km) *10^-5	Mass loss (g)	Erosion wear rate (mg/km) *10^-5
4 hours	0.0021	3.4177	0.0010	1.6274
7 hours	0.0029	4.7196	0.0017	2.7667
12 hours	0.0038	6.1844	0.0033	5.3706
20 hours	0.0051	8.3001	0.0042	6.8354
25 hours	0.0064	10.415	0.0052	8.4628

(III)Concentration- 70:30%:750 rpm:

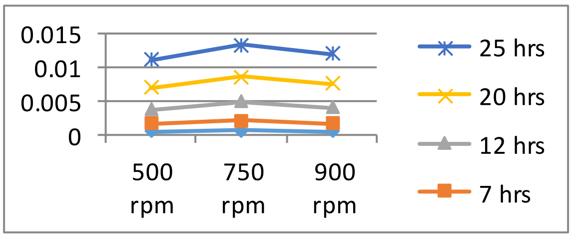
Time	Alumina		Aluminum-Titanium	
	Mass loss (g)	Erosion wear rate (mg/km) *10^-5	Mass loss (g)	Erosion wear rate (mg/km) *10^-5
4 hours	0.0003	0.4882	0.0001	0.1627
7 hours	0.0005	0.8137	0.0003	0.4882
12 hours	0.0005	0.8137	0.0004	0.6509
20 hours	0.0009	1.4647	0.0007	1.1392
25 hours	0.0004	0.6509	0.0002	0.3254

1.FOR 80:20%

A.MASS LOSS VS SPEED:

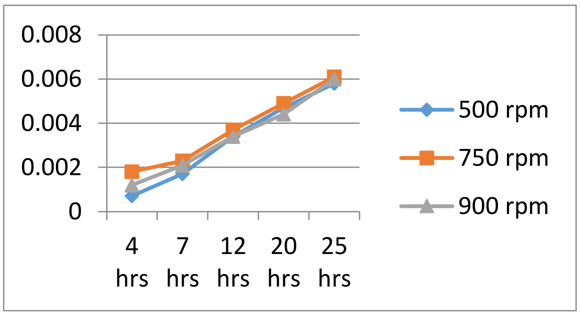


ALUMINA

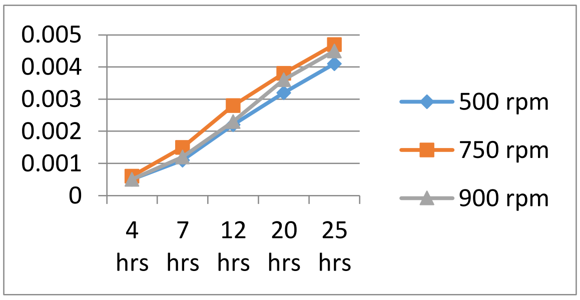


ALUMINIUM-TITANIUM

B.MASS LOSS VS TIME:

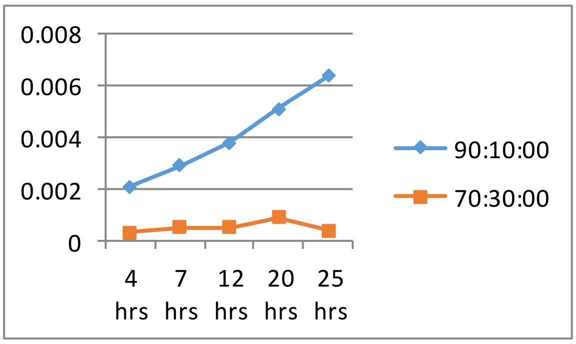


ALUMINA

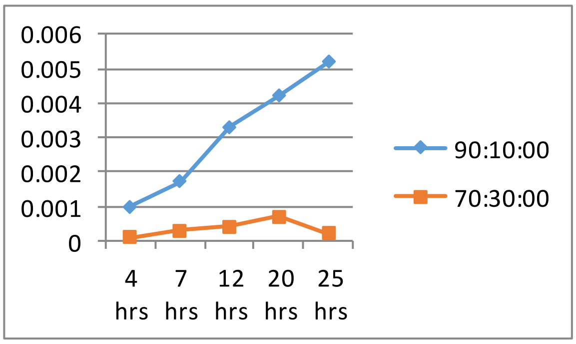


ALUMINIUM-TITANIUM

2. MASS LOSS VS TIME FOR VARYING CONCENTRATIONS (90:10 & 70:30)



ALUMINA

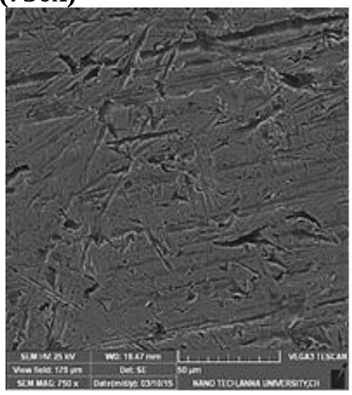


ALUMINIUM-TITANIUM

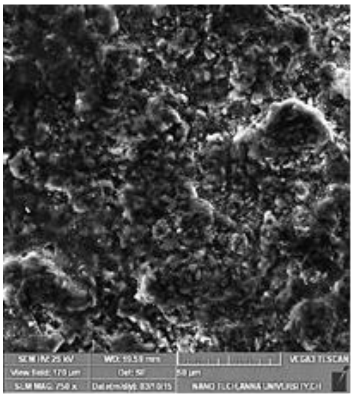
SEM OBSERVATION

FIG 4-10 shows the SEM images of Alumina and Aluminium-titanium coatings that were tested for 25 hours in pot erosion tester.

At 90:10 Concentration: (750x)



Alumina

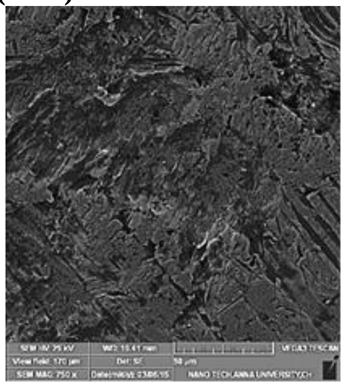
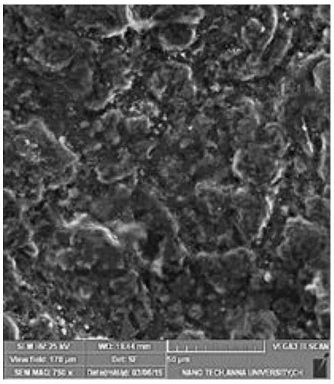


Aluminium-Titanium

The eroded alumina specimen shows characteristic erosion streaks that implies regions where the abrasives have eroded the material. On the other hand Aluminium-titanium specimen shows pits and craters that indicate respective oxide formation that retards surface erosion resulting in lesser mass loss.

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

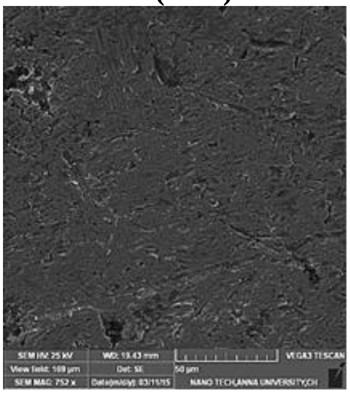
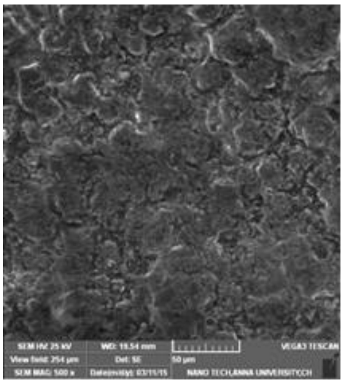
At 80:20 Concentrations: (750x)

Alumina **Aluminium-Titanium**

The alumina specimen shows irregular surface morphology highlighted by the formation of dents and erosion streaks. Aluminium-Titanium specimen shows its oxide built up surface characterized by irregular flakes.

At 70:30 Concentration: (750x)

Alumina **Aluminium-Titanium**

Both the above specimens show minimal signs of craters or dents. This implies that there is minimum mass loss resulting in almost minimal erosive wear. Aluminium –Titanium also results in lesser build-up of oxide layers.

CONCLUSION

Through this study it was found out that at optimum speed and concentration erosion wear rate and mass loss is maximum. This is because at higher and lower speeds there is either too much whirl speed or not enough whirl speed that results in micro cutting or chipping. At higher speeds the centrifugal force takes the slurry to the edges of the pot erosion tester thereby reducing the impact of slurry on the specimens. At lower speeds the impact is too weak to cause considerable erosion. Too much concentration of quartz particles results in a dense and packed slurry that has minimal impact on the specimen therefore reduced erosion. In the same way slurry with very less quartz concentration is very weak to cause any chipping or micro cutting.

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