Wear performance of Plasma Transferred Arc deposited layers

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ABSTRACT In this study, the effects of dilution on the wear behavior of PTAW (Plasma Transferred Arc Welding) Inconel 625, Inconel 718 and Stellite 6 overlays on Nimonic 80A were investigated. In order to evaluate the wear performance, two-body and three-body abrasive wear test, and dry sliding wear test were performed. According to wear tests, the wear rate of deposit with dilution 30% was higher than that of dilution 10% by 10%, and it was also found the plastic deformation near worn surface.

1. Introduction

In conventional exhaust valve spindles, the materials primarily used are heat resistant Nimonic 80A having a Stellite 6 alloy deposited over it [1,2]. However, there are cost problems associated with the use of Stellite 6 alloy overlayed by PTAW (Plasma Transferred Arc Welding) on Nimonic 80A exhaust valve spindles. Recently, the Inconel 625 and 718 are being substituted for Stellite 6 because of similar hot corrosion resistance with Stellite 6 and lower costs.

When a coating is overlayed on the substrate in PTAW of dissimilar materials, dilution between overlay and substrate inevitably occurs. Therefore, the chemical mixing causes the resultant microstructure to change. The wear performance of materials depends strongly on the microstructures.

This articles reports on the characterization and abrasive and pin-on-disk dry sliding wear performance of Ni and Co-base alloys deposited by PTA process. Two Ni-based gas atomized powders, (Inconel 625 and 718) and Co-based powder, (Stellite 6) were weld surfaced by the PTA process and then evaluate their wear performance to study the effects of dilution.

2. Experimental Procedure

2.1 Coating preparation

The Inconel 625 , 718 and Stellite 6 alloy powders were deposited on Nimonic 80A which is used in the exhaust valve spindle using PTAW. The compositions of the alloys used in this study are given in Table 1. To observe the wear performance with dilution, Inconel 625 , 718 and Stellite 6 PTAW overlays were formed with 10% and 30% dilution. The PTA machine used is a Eutronic 375 system. Nimonic 80A alloy with a thickness of 15 mm was used as substrates.

Table 1. Alloy compositions(wt.%)

Materials	Ni	Co	Cr	Fe	W	Ti	Nb	Mo	C	Si
Nimonic 80A	Bal.	-	17.57	1.43	-	2.50	-	-	0.070	0.016
Inconel 625	Bal.	-	19.76	2.74	-	0.10	3.56	8.50	0.058	0.480
Inconel 718	Bal.	-	17.71	17.37	-	1.01	4.97	2.93	0.045	0.200
Stellite 6	3	Bal.	28	3	4.5				1.1	

2.2 Abrasive wear testing

Two-body abrasive wear testing was carried out using Sugaru wear tester. Buehler grinding paper #400 (grit size of 30 ㎛) was used for counter abrasive. The load chosen was 3 kg. The average linear speed was 0.07 m/sec and the total sliding distance was 202 m.

Three-body abrasive wear resistance was evaluated using a dry sand rubber wheel (DSRW) test equipment. Beach sand was sieved to 0.2 - 0.3 mm. Specimen size for abrasive wear testing was 25 x 55 x 6(t) mm.

2.3 Sliding wear testing

A pin-on disk tribometer was employed at room temperature without lubrication to evaluate the dry sliding wear resistance. A flat-ended stationary pin specimen (ϕ8 mm and length 15 mm) was rubbed against a rotating disk specimen with 30 mm of the pitch circle diameter. Pins with PTA deposits were cut into the desired wear specimens by electro-discharge machining after PTA weld-surfacing. The weight lost of pin was measured after total sliding distance of 3780 m with a balance up to 0.1 mg. The average of minimum three runs for each specimen is also reported.

3. Results and Discussion

3.1 Abrasive wear performance

Figs. 1 and 2 show the results of abrasive wear tests for each coatings. The weight loss as a function of the number of revolutions was linear for each specimen, starting from 400 revolutions for the two-body abrasive wear testing. As expected, both (two-body and three-body abrasive) wear resistance of the Stellite 6 is higher than those of the Inconel 625 and 718. It is also found that wear resistance of the specimens with 10% dilution is higher than that of the specimens with 30% dilution.

3.2 Sliding wear performance

PTA deposited Inconel 625 and Stellite 6 pins were tested against the disk of Nimonic 80A (HV 320) with several sliding speed and load. Fig. 3 shows the results of pin-on-disk wear test for both coatings with load variation. The coatings with 10% dilution exhibit better sliding wear resistance when compared to the coatings with 30% dilution for all test conditions. It is also found that Stellite 6 exhibits better sliding wear resistance than Inconel 625. In case of Stellite 6, the effect of dilution on sliding wear performance is negligible at low stress level, but great or severe at high stress level (about 3 MPa).

Fig. 4 shows the worn surface morphology of Inconel 625 deposit. It seems that signs of delamination wear mechanism are increased as the dilution of the pin specimens is increased. That is, the worn surface morphology of the pin specimen with 30% dilution is showing more splats than that of the pin specimen with 10% dilution.

4. Conclusions

1. Abrasive wear resistance of Stellite 6 is higher than that of Inconel 625 and Inconel 718. The wear rate of deposit layers with higher dilution was much higher than that of deposit layers with lower dilution.
2. Dry sliding wear resistance of Stellite 6 is higher than that of Inconel 625 except at high stress region. The wear rate of deposit layers with higher dilution was much higher than that of deposit layers with lower dilution.

5. References

[1] T. Moriyama et al.: Nimonic compound exhaust valve spindles for diesel engines via hot isostatic pressing, Materials Science and Technology, Vol. 10, (11) 1994, pp. 993-1001

[2] J.R. Nicholls: Coatings and hardfacing alloys for corrosion and wear resistance in diesel engines, Materials Science and Technology, Vol. 10, (11) 1994, pp. 1002-1012

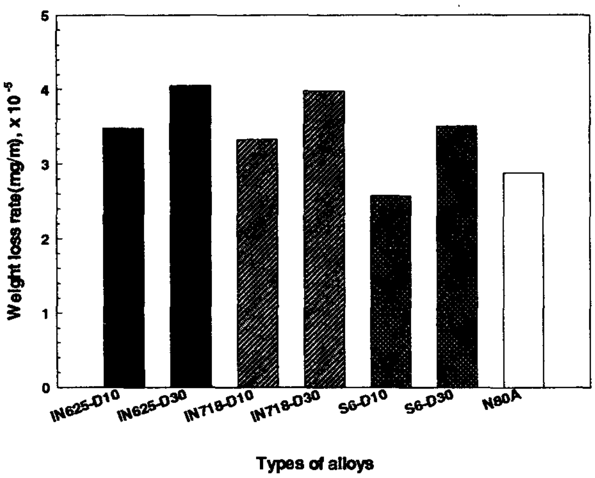

Fig. 1 The results of two-body abrasive wear test.

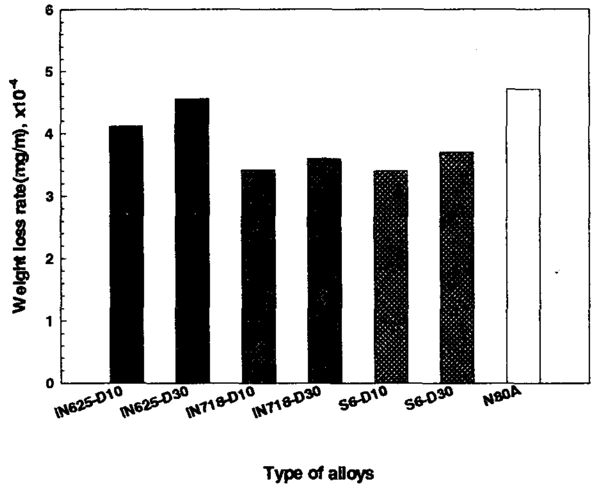

Fig. 2 The results of DSRW abrasive wear test.

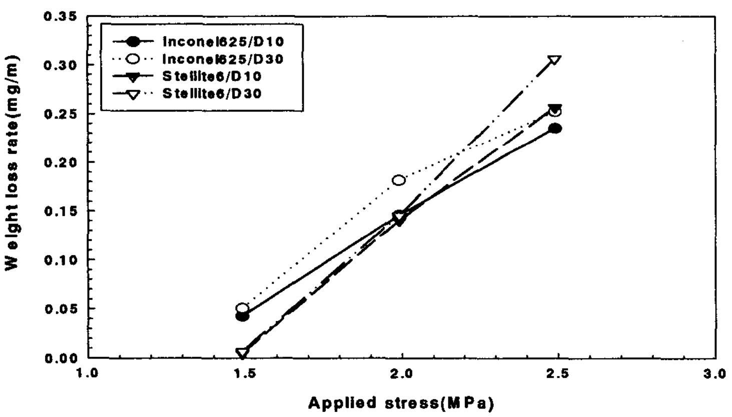

Fig. 3 The effect of applied stress on the weight loss rate of the pins the dry sliding wear test (Sliding speed; 0.42 m/s, Total sliding distance; 3078 m).

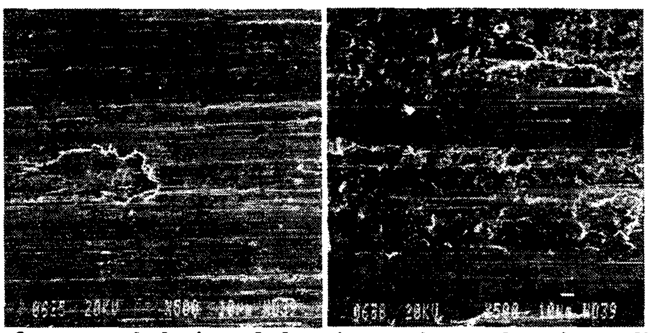

Fig. 4 Worn surface morphologies of the pin specimens for pin-on-disk dry sliding wear test (Applied stress; 1.49 MPa). (a) Inconel 625/D10 (b) Inconel 625/D30