International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 14 (2019) pp. 3283-3285

Wear Resistance of HVOF Sprayed Coatings under Abrasion Wear Testing

Piyapong Kamkun, and Prayoon Surin

Industrial Engineering Department, Faculty of Engineering,
Pathumwan Institute of Technology, Bangkok, 10330, Thailand.

Abstract

This research evaluated the wear resistance of the three types of high-velocity oxygen fuel (HVOF) sprayed deposition (e.g. AST 908, AST 915 and AST 928,). In this work, the abrasion tests concerned with the sliding wear behavior of the coated specimens were operated using a pin-on-plate apparatus and were analyzed by one-way analysis of variance (one-way ANOVA). The wear testing condition was accorded to the ASTM G133 standard at room temperature. The response of statistical analysis was the weight loss of specimens. The AST 928 was the best abrasion wear resistant at room temperatures.

Keywords: abrasion wear, high velocity oxygen fuel (HVOF), one-way ANOVA.

INTRODUCTION

The thermal sprayed coatings have occurred as a viable solution for a wide range of wear resistance applications to protect the surfaces of tools [1] and improve the service life of machine components [2], which has been several widely used in industry. The high velocity oxygen fuel (HVOF) sprayed coating method was used the industrial mechanical parts application under the abrasion wear situations such as gear, rotor, shaft, and turbine. The HVOF was referred to high mechanical property which involved higher abrasion, erosion, and corrosion [3-4]. Similar reports were exhibited by other researchers, the wear mechanisms were affected by the microstructure of the coatings and the test conditions, involving fracture and pull out of carbides, removal of splats and subsurface cracking [5]. The friction behaviour of heat-treated coatings was rationalized on the basis of the relative contribution of mechanical wear and oxidative wear [6]. This objective of the work was to investigate the weight loss on the wear resistance of HVOF sprayed AST 908, AST 915 and AST 928 coatings with respect to their statistical analysis.

EXPERIMENTAL PROCEDURE

The specimen was the medium carbon steel (Grade: JIS S50C) with the chemical composition as follows: 0.47-0.55 %C, 0.60-0.90 %Mn, 0.020-0.030 %P, 0.020-0.035 %S and 0.15-0.35 %Si. The powders were deposited on the medium carbon steel substrates (e.g. AST 908, AST 915, AST 928) with a coating thickness of 2000 µm using HVOF technique (SULZER METCO DIAMOND JET machine). The similar HVOF-process parameters of three HVOF-coating types (e.g. AST 908, AST 915, AST 928) and the chemical composition of three HVOF-coating types were shown in Table 1 and Table 2 respectively.

Table 1: The HVOF-process parameters.

HVOF-parameters	Type of powder		
	ATS 908	AST 915	AST 928
Oxygen (ft^3/min)	1900	2000	1950
Fuel (gallon/min)	6.00	6.00	5.75
Nitrogen (ft^3/min)	23 $\pm$ 2	21 $\pm$ 2	26 $\pm$ 2
Speed (rpm)	250-330	250-330	150-200
Coating temperature (ºC)	70-140	70-140	70-140
Coating distance (mm)	380	380	380

Table 2: The chemical composition of three HVOF-coating type.

Chemical composition	Type of powder		
	ATS 908	AST 915	AST 928
Tungsten carbide (WC)	✓	✓	✓
Chromium (Cr)	-	✓	✓✓
Nickel (Ni)	-	✓	✓✓
Cobalt (Co)	✓	-	-

The wear resistance analysis, the reciprocating wear behavior was considered with an instrument, which following by ASTM G133 standard (as shown in Fig. 1), using a WC-pin with a diameter of 2.5 mm. Two-body abrasive wear testing of coated specimens was carried out using weight loss. The coated specimens of size 25x50x6 mm were used for two-body abrasive wear testing. The two-body abrasive wear tests were operated at an applied load of 10 N and reciprocating velocity of 500 rpm.

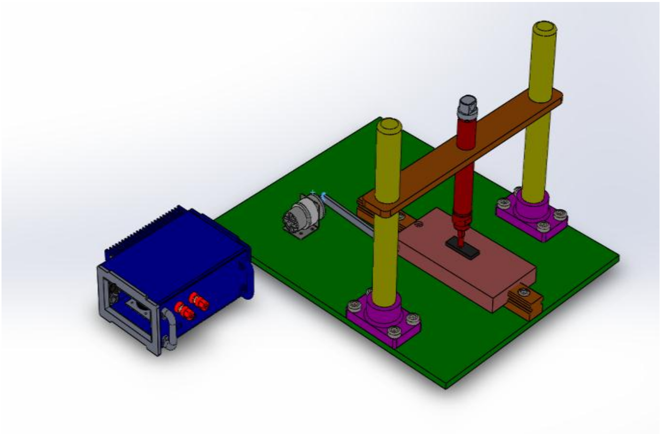

Fig.1: Schematic diagram of the reciprocating tester (ASTM G133)

The data on weight loss were measured for all coatings (e.g. AST 908, AST 915, AST 928) following the experimental procedure given in Table 3. The results obtained from the differentiation test specimens (n = 5 per case) were analysed to create whether the differences among cases were significant for each coating type. This was determined through one-way ANOVA, using the MINITAB software. According to Table 4, the P-value was also considered as criteria for understanding the significance of the model which P-value of less than 0.05 was identified as significant. In the corresponding Fig. 2, the main effect plot was shown a significant difference between the types of coating. Moreover, the best wear resistance of coating film was indicated the AST 928 because it was a lower weight loss.

Table 3: The data of one-way analysis of variance (ANOVA).

Type of coating	Weight Loss (g)				
AST 908	0.0004	0.0004	0.0006	0.0008	0.0005
AST 915	0.0006	0.0006	0.0008	0.0007	0.0010
AST 928	0.0004	0.0003	0.0004	0.0002	0.0001

Table 4: The result of one-way analysis of variance(ANOVA).

Source	DF	Sum of square	Mean square	F-value	P-value
Type of coating	2	0.000001	< 0.000001	10.93	0.002
Error	12	< 0.000001	< 0.000001		
Total	14	0.000001			

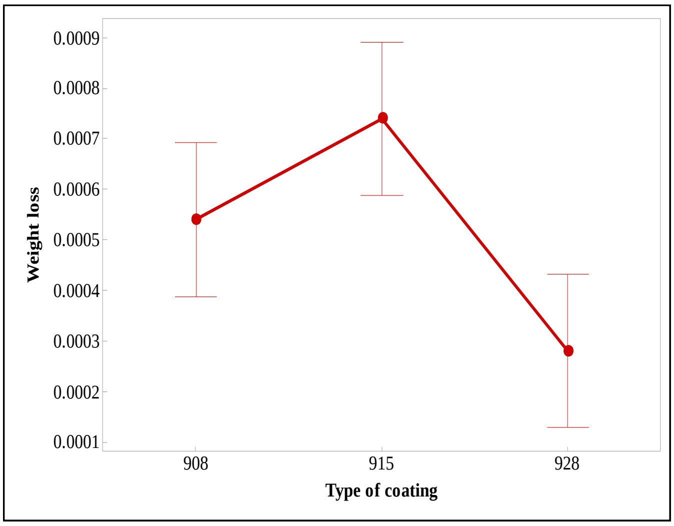

Fig.2: Main effects plot of mass loss.

CONCLUSION

In the present investigation, the best HVOF sprayed coating film between AST 908, AST 915 and AST 928 were studied. Based on the statistical result of the present work the following conclusion can be drawn. The best wear resistance of a type of coating was the AST 928 film.

ACKNOWLEDGEMENTS

The authors would like to thank MEMs laboratory in advanced surface technology CO., LTD. (AST) Thailand for conducting HVOF spray coating experiments, and Faculty of Engineering, Pathumwan Institute of Technology for financial support for research connected with this paper under an innovative research grant.

REFERENCES

[1] L. Pawlowski, “The Science and Engineering of Thermal Spray Coatings”, second ed., Wiley-VCH, Chichester, 2008.

[2] M. Couto, S. Dosta, J.M. Guilemany, 2015, “Comparison of the mechanical and electrochemical properties of WC-17 and 12Co coatings onto Al7075-T6 obtained by high velocity oxy-fuel and cold gas spraying”, Surface & Coatings Technology, 268, pp.180-189.

[3] K. Murugan, A. Ragupathy, V. Balasubramanian, K.Sridhar, 2014, “Optimizing HVOF spray process parameters to attain minimum porosity and maximum hardness in WC-10Co-4Cr coatings”, Surface & Coatings Technology, 247, pp.90-102.

[4] K. Szymanski, A. Hernas, G. Moskal, H. Myalska, 2015, “Thermally sprayed coatings resistant to erosion and corrosion for power plant boilers – A review”, Surface & Coatings Technology, 268, pp.153-164.

[5] N. Vashishtha, R.K. Khatirkar, S.G. Sapate, 2017, "Tribological behaviour of HVOF sprayed WC-12Co, WC-10Co-4Cr and Cr_3C_2-25NiCr coatings", Tribology International, 105, pp.55-68.

[6] N. Vashishtha, S.G. Sapate, P. Bagde, A.B. Rathod, 2018, "Effect of heat treatment on friction and abrasive wear behaviour of WC-12Co and Cr_3C_2-25NiCr coatings", Tribology International, 118, pp.381-399.