APPLICATION OF HVOF SPRAYED WC COATING UNDER FLUID CONDITION: A REVIEW

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ABSTARCT: The failure of fracturing tools like wear problem in gas and oil production can be improved by producing WC coatings using HVOF technique. Here the wear properties of the thermally sprayed WC coating based materials were studied. The wear tests were conducted under wet condition in water in oil fluid. From the experiment, we got the result that shows that the WC coated material showed higher hardness, lower friction co-efficient and higher wear resistance when compared to uncoated materials. Thereafter, wear behavior of WC coatings is obtained by the worn surface analyzing.

Key Words: tribological properties, thermal sprayed coatings, fracturing fluid, wear mechanism.

1. INTRODUCTION:

With the continuous demand on energy and increasing consumption of oil and gas resources, these have been stored in micro/ nano-pores whose permeability and physical property is low. These fluids along with dense particles are carried or slide on the tools of surface. This causes severe wear phenomenon. So, several development of engineering process is used to improve the surface properties. The main thing in this case is to improve wear resistance. The easiest way of getting metal matrix is thermal sprayed process. These coating deposition contribute better hardness, corrosion resistance and excellent wear. Therefore, many industries use thermally sprayed coatings under high temperatures for wear protection. These thermally sprayed materials contain hard particles. The coatings are made by spraying material on the surface in its molten state. Among all of these WC-10Co-4Cr is the most popular so far.

However, these WC coatings are applied in dry condition. Under this dry condition, both tribological and wear properties of HVOF sprayed are investigated. Along this a little research had been made in wet condition. The mixture of coatings is studied by using SEM, XRD and micro hardness tester. The results of this work provide information on reducing wear rate.

2. EXPERIMENTAL PROCEDURE

2.1 Materials required and coating process

For the coating preparation, AISI 4140 steel is selected. The material is cut into 25*25*5mm. after the cutting process, using acetone; material is cleaned in ultrasonic cleaning process. After this, coating deposition is done using Praxair-Tafa JP8000 HVOF spray technique.

2.2 Characteristics of coatings

The coatings composition is measured using X-ray diffractometer using Cu-K radiation at a 10^0 to 100^0 angle. The hardness of uncoated and coated surface is measured using micro hardness tester under 300g load for 15s. The worn surface is noted using scanning electron microscope with a X-ray spectroscopy system.
2.3 Tribological tests

The sliding wear tests of WC coatings materials are carried on pin on disc, which was designed according to ASTMG99-05. The equipment has precise sliding speeds, control of applied loads and positions of different loads on different specimen areas for a single test. Al_2O_3 pin is selected to slide against test specimen. The test is carried under 5N, 10N and 15N respectively with a 10mm/s of fixed sliding speed. The dry wear tests are carried under 298K temperature. The time taken was 1 hour for each test.

The wet wear tests were carried by the preparation of fracturing fluid that consists of diesel, water, span and tween 80. For analyzing wear resistance, wear rates were compared. And also to analyze wear behavior, friction co-efficients are also recorded. After the test was conducted the material was dry and it was measured using an electron balance.

3. RESULTS and CONCLUSION

3.1 Characterization of coating

By using SEM, it can be looked that the coating of material was successful. There were pores visible on the coating resulting in the down of strength of bonding. Using X-ray diffraction patterns, strong peaks of WC are identified on the surface of coating and a small amount of W_2C and C were also gained. Furthermore, these peaks were proportional to Fe. The coating has a higher hardness. It is clear from the experiment that hardness was increased from 250 to 1110HV. The hardness of WC coating material was 3 times the base metal. Thus production of hard coating on the substrate surface improves its wear resistance.

3.2 Wear behavior in dry condition

Friction is produced when there is a relative motion between two contact surfaces. The experiment conducted under load of 5N, 10N and 15N for 1 hour gives the friction co-efficient of uncoated and coated specimens. When compared with each other, friction co-efficient of uncoated materials were larger under 3 different loads. But however, friction co efficient in both coated and uncoated material decreased gradually with increasing loads. At lower loads, the roughness of surface was large. But at lower loads, the friction co efficient was in a decreased level.

From the test, it is obtained that these loads have impact on the wear rates of material. The maximum wear rate was 0.128mg/s under 15N which was higher than that of lower loads. The higher wear rate is due to higher friction and contact area. These results confirmed that WC coated material by HVOF improved the wear resistance of coated material.

3.3 Wear behavior in wet condition

The wear behavior of material is studied under fracturing fluid condition. From the test it can be seen that changes in co efficient of friction under different loads were same or similar to each other. In addition, the difference of co efficient of friction between these uncoated and coated materials under the same load was smaller. Thus it can be concluded that when compared to wear rates under dry condition, wear rates were smaller under wet condition. This shows the wear behavior has changed with the presence of W/O fracturing fluid. Under wet condition, water film, fluid temperature and viscosity of fluid also influence the wear behavior.

3.4 Wear surface analysis

Using scanning electronic micrographs, the effect of wear condition of uncoated and coated material is studied under dry friction condition with 10N load.

The worn morphologies such as material flow and damage are characterized. By this, severe plastic deformations occurred on uncoated material. By comparing, the wear resistance of coated material was narrower and shallower along the sliding directions. Moreover, oxidation, wear debris and cracks are found on the surface of coated material. Thus, by using high temperature in thermal spray technique, defects like weak bonding strength and unexpected porosity occur. When the pin slides along this specimen, due to weak interconnection, the semi-molten hard powder fell off. This caused formation of craters.

4. CONCLUSION

In this study, the success is gained by forming WC coatings on base material by HVOF. The wear behavior under wet and dry conditions were tested and investigated.
The following are the conclusion made

1. The final coated material consisted of mainly WC and a small amount of W_2C and C. This W_2C and C formation is due to decarburization of WC. The thickness was 355µm, the hardness of coated material gradually decreased from surface to substrate and the maximum micro hardness coating was about 3 times of the substrate.

2. While the wear rates increased from 5N to 15N and friction co efficient decreased gradually. Thereafter, the wear rates under dry conditions were higher than that under wet condition.

3. In dry conditions, the uncoated material destroyed easily and the adhesive wear occurred due to weak surface strength. For coated material, wear debris acted as cutting tool with different shapes and thus abrasive wear occurred.

4. In wet condition, fracturing fluid between pin and counterpart acted as lubricant and helped to reduce the wear loss.

4.0 REFERENCES

[1] J. Wallace, C.S. Kabir, C. Cipolla, Probing diagnostic fracture injection tests in unconventional reservoirs, J Petrol Sci Eng 143 (2016) 245-257.

[2] D.Y. Ding, Y.S. Wu, L. Jeannin, Efficient simulation of hydraulic fractured wells unconventional reservoirs, J Petrol Sci Eng 122 (2014) 631-642.

[3] C. Zheng, Y.H. Liu, H.X. Wang, C. Chen, J. Qin, Z.K. Liu, Y. Shen, Numerical simulation of the conveyance characteristics of fracturing ball in the horizontal section, J Nat Gas Sci Eng 34 (2016) 401-411.

[4] M. Zhang, M.D. Becker, L.F. Ayala, A similarity method approach for early-transient multiphase flow analysis of liquid-rich unconventional gas reservoirs, J Nat Gas Sci Eng 28 (2016) 572-586.

[5] J.A.R. Wesmann, N. Espallargas, Effect of atmosphere, temperature and carbide size on the sliding friction ofself-mated HVOF WC-CoCr contacts, Tribol Int 101 (2016) 301-313.

[6] L. Benea, S.B. Basa, E. Danaila, N. Caron, O. Raquet, P. Ponthiaux, J.P. Celis, Fretting and wear behaviors of Ni/nano-WC composite coatings in dry and wet conditions, Mater Des 65 (2015) 550-558.

[7] N. Vashishtha, R.K. Khatirkar, S.G. Sapate, Tribological behaviour of HVOF sprayed WC-12Co, WC-10Co-4Cr and Cr_3C_2-25NiCr coatings, Tribol Int 105 (2017) 55-68.

[8] S. Hong, Y.P. Wu, G.Y. Li, B. Wang, W.W. Gao, G.B. Ying, Microstructural characteristics of high-velocity oxygen-fuel (HVOF) sprayed nickel-based alloy coating, J Alloys Compd 581 (2013) 398-403.

[9] F. Haftlang, A. Habibolahzadeh, M. H. Sohi, Comparative tribological studies of duplex surface treated AISI 1045 steels fabricated by combinations of plasma nitriding and aluminizing, Mater Des 60 (2014) 580-586.

[10] T.M. Yang, Q.P. Wei, Y. Qi, Y.J. Wang, Y.N. Xie, J.Q. Luo, Z.M. Yu, Microstructure evolution of thermal spray WC-Co interlayer during hot filament chemical vapor deposition of diamond thin films, J Alloys Compd 639 (2015) 659-668.

[11] G. Bolelli, L.M. Berger, M. Bonetti, L. Lusvarghi, Comparative study of the dry sliding wear behaviour of HVOF-sprayed WC-$(W,Cr)_2$C-Ni and WC-CoCr hardmetal coatings, Wear 309(1) (2014) 96-111.

[12] M.S. Mahdipoor, F. Tarasi, C. Moreau, A.Dolatabadi, M. Medraj, HVOF sprayed coatings of nano-agglomerated tungsten-carbide/cobalt powders for water droplet erosion application, Wear 330 (2015) 338-347.

[13] M. Li, P.D. Christofides, Computational study of particle in-flight behavior in the HVOF thermal spray process, Chem. Eng. Sci. 61(19) (2006) 6540-6552.

[14] P.K. Aw, A.L.K. Tan, T.P. Tan, J.H. Q, Corrosion resistance of tungsten carbide based cermet coatings deposited by high velocity oxy-fuel spray process, Thin solid films 516(16) (2008) 5710-5715.

[15] A.K. Basak, P. Matteazzi, M. Vardavoulias, J.P. Celis, Corrosion-wear behaviour of thermal sprayed nanostructured FeCu/WC-Co coatings, Wear 261(9) (2006)1042-1050.

[16] M.P. Nascimento, R.C .Souza, I.M. Miguel, W.L Pigatinc, H.J.C. Voorwald, Effects of tungsten carbide thermal spray coating by HP/HVOF and hard chromium electroplating on AISI 4340 high strength steel, Surf. Coat. Technol. 138(2) (2001) 113-124.

[17] S. Al-Mutairi, M.S.J. Hashmi, B.S. Yilbas, J. Stokes, Microstructural characterization of HVOF/plasma thermal spray of micro/nano WC-12% Co powders, Surf. Coat. Technol. 264 (2015) 175-186.