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Wear Behaviour of FeCrMoW Hardfaced Coating

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Abstract
Iron based alloys are used extensively to overcome the effect of wear through the process of thermal spraying. For the present study, FeCrMoW coating were produced through High Velocity Oxygen Fuel (HVOF) thermal spraying. Substrate used for the present study is IS2062. Wear Test of the hardfaced coating was performed using pin on disc machine. The effect of Load, Sliding Velocity and Temperature on wear was analysed using RSM.
It was analyzed that wear had a direct relation with Load, Sliding Velocity and Temperature. The effect of load on the rate of wear was predominant over sliding velocity and temperature. It was also observed that hardness has significantly improved after coating.

Keywords: Design of experiments; Hardfacing; RSM; Wear.

Introduction

Life of machinery and machine part is dependent on its rate of wear and machine parts are subjected to fracture due to effect caused by wear. Different modes of wear are abrasion, erosion, adhesive, impact and corrosion. Chavada et. al. [1]To enhance the wear resistant properties, material of better wear resistant properties is deposited on the surface of similar or dissimilar material. This technique is termed as hardfacing. The benefit includes long lasting service life, high production, minimized downtime etc. P.Kumari et.al.[2]. Hardfacing, a surface reconstructing technique, is used to reconstruct the surface of a material. Hardfacing material and chemical composition decides the successful outcome of the process for a particular application. Sanjay Kumar et al. [3]. Iron-based hardfacing alloys are widely used to protect machinery equipment exposed either to pure abrasion or to a combination of abrasion and impact. R. Chotěborský et al. and M. Kirchgabner et. al. [4].
Hardfacing alloys exhibits is lower wear rate in comparison to mild steel. The hardfacing alloy consisting highest chromium content shows the lowest wear rate, concluded that in comparison to other parameters, load has the most dominant effect on abrasive wear. Navas et. al. [5]. If WC is added up to 20% in WC-Co-Cr, hardness and abrasive wear résistance increases and further addition do not have much effect. Maiti et. al. [6]. Studying the abrasive wear behaviour of Fe-Cr-C hardfacing alloys depicted that the wear rate increased linearly with sliding distance and was not always directly proportional to load. Buchanan (2007)[7].

Material and Methods

Sample preparation
FeCrMoW alloy of 1.6mm diameter was coated on IS 2062 plate of 10mm thickness using High Velocity Oxygen Fuel (HVOF). The chemical composition of filler wire is given in table 1. The samples were cut in required size from a single plate, and following preparatory treatment was given prior to thermal spraying:
1. Smut removal: Specimens were first dipped in 15% HNO_3 for nearly about 5 –10 minutes. Were then rinsed in tap water followed by hot air drying.
2. Final cleaning: Samples were chemically cleaned and were brushed with stainless steel wire brush then were swabbed using acetone. P.Kumari et.al [8].

Table 1: Chemical composition of filler wire

Element	Cr	C	Mo	B	W	Si	Nb	Fe
%	21	3	12	0.63	10	0.6	0.81	Balance

For the HVOF process acetylene fuel and oxygen flame was used as a source to create heat. Table 2 gives the operating parameters of HVOF to develop coating.

Table 2: Operating parameters of HVOF Process

Parameters	Value
Spraying voltage (V)	32
Spraying current (A)	150
Primary air pressure (MPa)	0.42
Secondary air pressure (MPa)	0.28
Stand-off Distance (mm)	200
Number of passes	2

The coated plate was cut out using wire EDM in 10mm x10mm size. These specimens as shown in Figure 1 were then welded to 8mm diameter cylindrical pin in such a manner that the hardfaced face should be kept opposite. The objective was to clamp these test specimens on pin on disc machine which is used in present research for wear test. The material selected for disc of pin on disc machine was ASTM M2 Steel of 165 mm diameter. Hardness of the disc was improved by electric furnace tempering.

Figure 1: Specimen for wear test

Factorial design technique was used to conduct the experiments and is shown in the form of a design matrix where the rows refers to different trials and the column refers to the coded values of the input process parameters. P.Kumari et.al [9].The design matrix developed for the purpose of experimentation is given in table 3.

Table 3: Design Matrix

S.No.	**Load (L)**	**Sliding Velocity (SV)**	**Temperature (T)**
1	+	+	+
2	-	-	-
3	+	+	-
4	+	-	+
5	-	+	+
6	-	+	-
7	+	-	-
8	-	-	+

The independently controllable process parameters were identified through literature survey. It was observed that the parameter which influences the wear most were Load, Sliding Velocity and Temperature.

Then the upper and lower limits of these process control variables were recorded through pilot study. The recorded values are shown in table 4 below.

Table 4: Wear test parameters

S.No.	**Variables**	**Levels**	
		Lower	**Upper**
1.	Load (N)	15 (-)	50 (+)
2.	Sliding velocity (m/sec)	1 (-)	2 (+)
3.	Temperature (oC)	50 (-)	100(+)

Test specimens were then cleaned with acetone to make the surface free from grease, dust and other impurities on test surface. Then the test pieces were weighed on an electronic balance machine having sensitivity of up to five decimal places. Test pieces were then mounted on the pin on disc machine for wear testing as per the design matrix. After performing the test, the specimens were again washed with acetone to remove any debris present and then were properly dried. Finally, specimens were weighed again on electric weighing machine. To determine the wear, difference in weight of test specimen was recorded and is shown in table 5.

Table 5: Observed wear

Experiment No.	Wear Volume
1	0.0132
2	0.014
3	0.016
4	0.0152
5	0.0125
6	0.016
7	0.0182
8	0.0112

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Results and Discussion

The response function Y, representing the wear volume, could be represented as:

$$Y = f (L, SV, T) \quad (1)$$

Where, the response variable, 'Y' could be any of the wear. Load (L), Sliding velocity (SV) and Temperature (T) were taken as direct process control variable. Assuming a linear relationship, the above expression can be written as:

$$Y = b_0 + b_1L + b_2SV + b_3T + b_4L*SV + b5L*T + b_6 SV*T \quad (2)$$

Where, b_0, b_1,……………b_6 are the coefficients of the polynomial equation.

For determining the coefficients of the model, regression analysis was used. For predicting wear, the following model was used:

W= 98.769 + 16.061S.V– 4.757L+17.097S.D+0.047S.V*L–.0475S.V*S.D–0.047L*S.D. (3)

The estimated value of wear is mentioned in the table 6 below.

Table 6: Modelled Wear

Experiment No.	Modelled Wear
1	0.01296
2	0.01423
3	0.01623
4	0.01496
5	0.01226
6	0.01623
7	0.01796
8	0.01143

Scatter plot as shown in figure 2 validates the developed models fully.

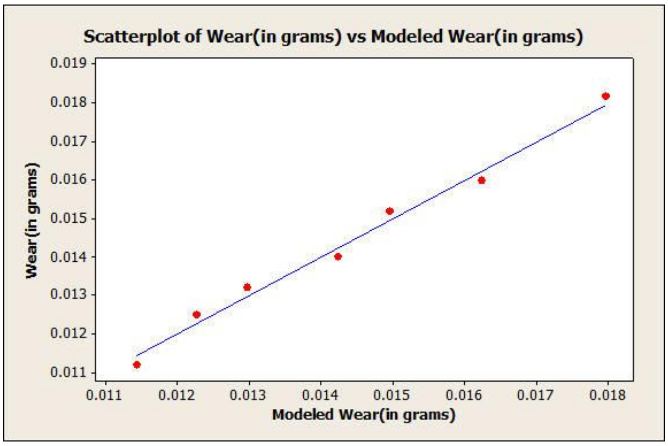

Figure 2: Scatter plot

For the purpose of depicting the wear rate due to the effect of various direct and interaction parameters coded values were feed in the final model of wear by varying one input parameter at a time and keeping others at fixed value.

The effect of main and interaction parameters on wear is discussed as under:
Effect of load, sliding velocity and temperature on wear was analysed. Main effect and interaction effect of all the wear parameters i.e. load (L), sliding velocity (SV) and Temperature (T) are shown in Fig. 3 and 4 respectively.

It was noticed that load has the most dominant effect on wear in comparison to temperature and sliding velocity. Interaction parameters do not show any significant effect.
Figure 5, 6 and 7 represents the Contour Plot for different input parameters.

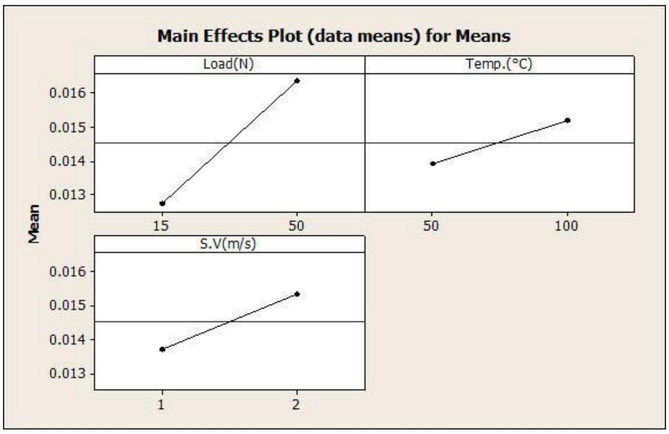

Figure 3: Main Effect Plot

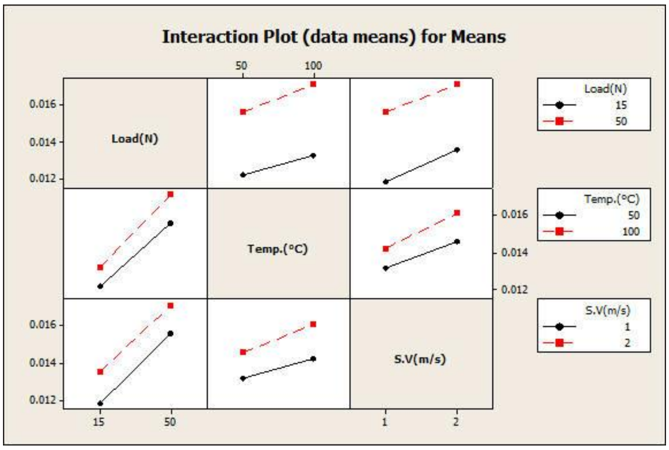

Figure 4: Interaction Effect Plots

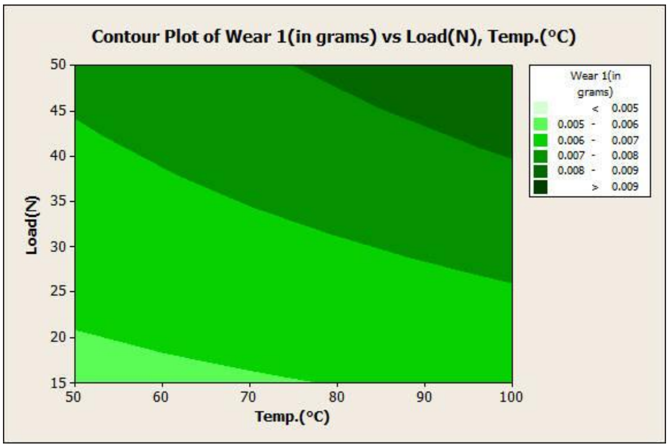

Figure 5: Contour Plot of wear for load and Temperature.

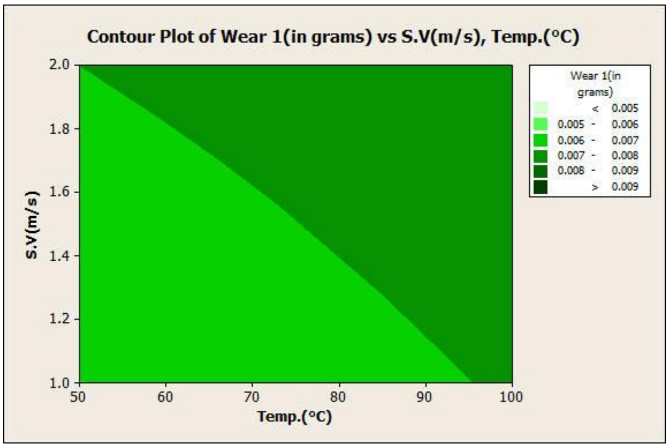

Figure 6: Contour Plot of wear for sliding velocity and Temperature.

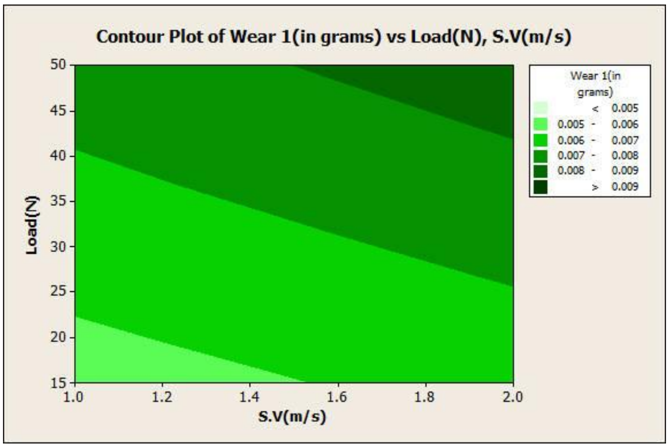

Figure 7: Contour Plot of wear for sliding velocity and load

Conclusion

The conclusions are drawn from the study of mathematical models as well as the experiments conducted in actual condition. Important results are as follows:

1. Factorial design technique is a valuable and powerful tool, for the design of experiments
2. Scatter diagram validate the accuracy of the model.
3. Wear is in direct relation with Load, Sliding velocity and Temperature.
4. The effect of load on the rate of wear is strongest over sliding velocity and temperature.
5. Wear rate of any material is in inverse relation with the hardness of that material.

References

[1] Chavada, P.T., Jayesh, V.D. and Patel, T.M., 2013. A review on parametric optimization of MIG welding for medium carbon steel using FEA-DOE hybrid modeling. International Journal for Scientific Research & Development. 1 (9), 2321-2334.

[2] Kumari, P. and Singh, R.P., 2016. Optimization of welding parameters for weld bead width in GMAW using genetic algorithm. ISFT, 5th International Symposium on Fusion Science and Technology.

[3] Sanjay Kumar, D.P. Mondal, and A.K. Jha, 2000, Effect of Microstructure and Chemical Composition of Hardfacing Alloy on Abrasive Wear Behavior Journal of Materials Engineering and Performance Volume 9(6), 655.

[4] R. Chotěborský, P. Hrabě, M. Müller, J. Savková, M. Jirka, M. Navrátilová 2009. Effect of abrasive particle size on abrasive wear of hardfacing alloys. Research in Agricultural Engineering. Vol. 55, no. 3.

[5] Navas, A.E. and Nassar, E.E., 2011. Design and fabrication of a wear testing machine leonardo electronic. J. Practices and Technologies. ISSN 1583-1078, 39-48.

[6] A.K. Maiti, N. Mukhopadhyay, R. Raman, 2007 'Effect of adding WC powder to the feedstock of WC–Co–Cr based HVOF coating and its impact on erosion and abrasion resistance, Surface & Coatings Technology 201, 7781–7788.

[7] Buchanan V.E. , Shipway P.H., McCartney D.G. 2007, Microstructure and abrasive wear behaviour of shielded metal arc welding hardfacings used in the sugarcane industry. Wear 263, 99–110

[8] Kumari, P. and Singh,R.P., 2015. Abrasive wear mathematical model of 140MXC nano structured hardfacing. International Journal of Innovative Research in Science, Engineering and Technology, 4 (8), 7321-7330.

[9] Kumari, P. and Singh, R.P., 2015. Development of mathematical models for prediction of weld bead geometry of hardfaced steel. International Journal of Applied Engineering Research, 10(17), 38509-38525.