Design of Experiment of Hard Facing For Better Performance By Using Taguchi Experimental Design

Parwinder Singh[1], Harvinder lal[2]

[1,2]Department of Production Engineering

[1,2]Ramgarhia Institute of Engineering and Technology

Abstract: This paper presents a simple Experiment to improve the Hard facing and wear loss in the material by using Taguchi method. Material coating we used is Satellite 1.material factors/consideration factors we are taking is Applied Load (In kgs.), Sliding velocity (mm/minute), Welding Current (Amp.), Filler rod Diameter(mm).Taguchi method is very well proved in this experiments for finding or obtaining Hard facing (High) and wear loss(min).also This experiment is well suitable with the previous ones[20].

Keywords: Surface engineering, Hard facing, Wear, Electrodes, Welding techniques.

I. INTRODUCTION

Surface engineering [2] for Tribological [18] applications aims at two basic objectives:

1. To increase the Hardness of the surface material
2. To modify Wear Behavior.

The tribological interactions of a solid surface's exposed face with interfacing materials and environment may result in loss of material from the surface. The process leading to loss of material is known as "wear"[2]. Major types of wear include abrasion, friction (adhesion and cohesion), erosion, and corrosion. Wear can be minimized by modifying the surface properties of solids by one or more of "surface engineering" processes (also called surface finishing) or by use of lubricants (for frictional or adhesive wear).If a component is not completely separated from its counter-face by a fluid film, its tribological behavior critically depends on the properties of the contacting surfaces and hence the choice of contacting materials becomes important. Thus, a material selected on the basis of strength and bulk properties may be unsuitable for its tribological properties. It is well known that wear resistance of surface increases with hardness and hence to resist wear one should go for a material of high hardness.

The method used in surface engineering may be broadly divided into two categories:

1. Surface treatment
2. Surface coatings.

Surface Treatment:

Surface treatment techniques involve heating materials in reactive or non-reactive environment to yield micro-structural changes or the formation of chemical compounds only on the top layer of few micron thicknesses. Sometimes, both micro-structural and chemical compound formations are achieved in single treatment.

Surface Coatings:

Surface coatings can be applied over a wide range of thickness from a few micrometers to several millimeters. Coatings can be classified as soft coatings with low or moderate-to-low friction and hard coatings with wear resistance and moderate friction. Chromium, nickel, cobalt and nickel- based alloys, Stellite 1s; triballoys [18]are very common as coating materials

Many coating deposition techniques are available and these may be classified into three broad categories:

- Hardfacing
- Vapour deposition
- Miscellaneous deposition processes.

Hardfacing is used for depositing thick coatings of hard wear-resistant material. Vapour deposition techniques are used to deposit thin and reproducible coatings with excellent adhesion and significant flexibility. Miscellaneous deposition processes are widely used for application of polymer coatings, non-metallic coatings and composite for wear and corrosion resistance.

Hard facing [1]:

Hard facing is a metalworking process where harder or tougher material is applied to a base metal to resist wear and prolongs working life. Hard facing is also known as hard surfacing. The harder material is welded to the base material, and is generally takes the form of specialized electrodes for arc welding or filler rod for TIG and oxyacetylene welding. Hard facing is one of the most useful and economical ways to improve the performance of components submitted to severe wear conditions.

Applications of hard facing:

Hard facing is commonly used on heavy machinery in the following industries:

- Construction and Excavation: Tractor and shovel parts, buckets, excavator teeth, drive sprockets, etc.
- Mining, crushing and grinding: Dragline chains and buckets, shaker pan conveyers, ball mill scoops, etc.
- Cement and Brick: Screw conveyers, pulverizer mill components, vibratory screens, etc.
- Iron and Steel: Machine rails, sintering plant pallets, tap hole drill bits, etc.

Advantages of hard facing

- Reduces Cost: Restoring a worn part to "as new" condition generally costs between 20-70% of a brand new replacement part.
- Prolongs Equipment Life: Service life increases of 3 to 10 times are common with properly overlaid parts.
- Reduces Downtime: Parts last longer and fewer shutdowns are required.
- Less Spare Parts Inventory: There is no need to keep numerous spare parts when worn parts can be rebuilt.

WEAR [2]:

Generally products lose their usefulness due to three main reasons; obsolesce, breakage and wear. From tribological considerations, wear is the most important reason amongst the three. Wear has been defined in different ways by different persons and agencies but all, at the end, mean the same.

The wear can be categorized into different types based on the sources/causes of wear.

1. Adhesive Wear
2. Abrasive Wear
3. Erosive Wear
4. Fretting Wear
5. Corrosive Wear
6. Others

Although wear cannot be eliminated completely, yet it can be reduced to some extent by different wear prevention methodologies.

1) Better Material: Select suitable wear resistant materials checking technological or economic factors.

2) Coatings: As wear is a surface phenomenon, it can be reduced using protective coatings on the contacting surfaces. There are so many coating methods according to particular need and requirements.

3) Lubrication: Lubrication is the most important factor for wear considerations. The main objective of lubrication is to reduce the severity of friction and wear in addition to performing other functions.

4) Contact pressure: Ensure that the actual contact pressure does not exceed the allowable contact pressure for that material and for that application. This may have different values for different materials. Some hand books specify such allowable contact stresses.

5) Temperature: Ensure that working temperature remains within limits as higher temperature softens most metals and lower temperature embrittles some materials.

6) Misalignment: Try to avoid misalignment, if some misalignment is a must, use materials/ designs which can accommodate the same.

7) Environment: Reduce abrasive, corrosive and other hostile environment.

8) Maintenance: Use proper maintenance schedules, procedures, methods to minimize wear problem

II. EXPERIMENTAL DESIGN

Taguchi [8] Experimental Design for wear test Taguchi method is important tool for the robust design in obtaining the process and product conditions which are least sensitive to noise to produce high quality products with low manufacturing costs. It involves various steps of planning, conducting and evaluating the results of specially designed tables called “orthogonal array” experiments to study entire parameter space with minimum number of trials to determine the optimum levels of control parameters. Taguchi method combine experiment design theory and quality loss function .Taguchi method recommends the use of loss function which is then transformed into a S/N ratio to measure the performance characteristic deviating from the desired value and then S/N ratio for each level of process parameters is evaluated based on average S/N ratio response analysis and greater S/N ratio is corresponding to better quality characteristic irrespective of category and quality is evaluated based on average S/N ratio response analysis and greater S/N ratio is corresponding to better performance characteristic regardless of category and quality.

Process parameters

- Applied Load (In kgs.)
- Sliding velocity (mm/minute)
- Welding Current (Amp.)
- Filler rod Diameter(mm)

Abrasive wear test [2]:

The materials considered for this experiment is mild steel samples with dimensions 100mm x 50 mm x 10 mm. The test was conducted on a machine called Pin on disc machine. The sample was mounted perpendicularly on a stationary vice such that it’s one of the face is forced to press against the abrasive that is fixed on the revolving disc. Hence it is the abrasive paper that tends to wear the surface of the samples. When the disc rotates for a particular period of time, the sample can loaded at the top to press against the disc with the help of a lever mechanism.

In this experiment the test can be conducted with the following parameters

(1) Load

(2) Time

In the present experimental work, test is conducted at three different loads i.e. at 1.5Kg, 3 Kg, 5 Kg. for a time period of 10 minutes for each specimen. The abrasive paper used was Emery, 80 grade size.

The table shown below gives the experimental results obtained after conducting wear test using Taguchi array:

Applied load	sliding velocity	welding current	fiiler rod diameter	weight loss
1.5	35	190	3.5	5
1.5	35	200	5	4
1.5	35	220	7	7.1
1.5	15	190	3.5	5.6
1.5	15	200	7	6.5
1.5	15	220	3.5	9
1.5	25	190	7	7.4
1.5	25	200	3.5	9.5
1.5	25	220	5	9.5
3	25	190	5	5.3
3	25	200	7	5.4
3	25	220	3.5	15.5
3	15	190	7	11.5
3	15	200	3.5	11.5
3	15	220	5	21.1
3	35	190	3.5	9.5
3	35	200	5	13
3	35	220	7	26.3
5	25	190	7	8.3
5	25	200	3.5	13.9
5	25	220	5	17.7
5	15	190	3.5	10.1
5	35	200	5	17.9
5	35	220	7	25
5	35	190	5	13.5
5	15	200	7	17.7
5	15	220	3.5	25.5

Hardness [15][1] Test:

Rockwell hardness testing is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, hardness correlates with strength, wear resistance, and other properties. This method consists of indenting the test material with a diamond cone or hardened steel ball indenter. The indenter is forced into the test material under a preliminary minor load F0 usually 150kg. When equilibrium has been reached, an indicating device, which follows the movements of the indenter and so, responds to changes in depth of Penetration of the indenter, is set to a datum position. While the preliminary minor load is still applied an additional major load is applied with resulting increase in penetration. When equilibrium has again been reach, the additional major load is removed but the preliminary minor load is still maintained. Removal of the additional major load allows a partial recovery, so reducing the depth of penetration. In present experimental work Rockwell hardness was measured on at three different positions on each specimen and the average value of hardness was taken

III. RESULTS

There are twenty seven different tests were conducted using the control factor combinations in the specified orthogonal array table value. Nine specimens were prepared for each set of parameters to prepare complete response table. Taguchi method uses the S/N (signal-to noise) ratio. S/N ratio is used to determine the most significant factor. There are three types of S/N ratio criteria for optimization; smaller the best, larger the better and nominal the best. To get the better Performance of results, smaller the weight loss is desired and hence smaller the best criteria has been selected and following expression was used for analysis.

$$S/N\ ratio = -10 \log [1/ni=\ln(1/yi^2)]$$

Where, ni = S/N ratio for ith experiment yi = Observed value for ith experiment

n= Total number of observed value for ith experiment.

Results of Wear Test:

SNO	weight loss	SN RATIO
1	5	13.9794
2	4	12.0412
3	7.1	17.0252
4	5.6	14.9638
5	6.5	16.2583
6	9	19.0849
7	7.4	17.3846
8	9.5	19.5545
9	9.5	19.5545
10	5.3	14.4855
11	5.4	14.6479
12	15.5	23.8066
13	11.5	21.214
14	11.5	21.214
15	21.1	26.4856
16	9.5	-19.5545
17	13	-22.2789
18	26.3	-28.3991
19	8.3	-18.3816
20	13.9	-22.8603
21	17.7	-24.9595
22	10.1	-20.0864
23	17.9	-25.0571
24	25	-27.9588
25	13.5	-22.6067
26	17.7	-24.9595
27	25.5	-28.1308

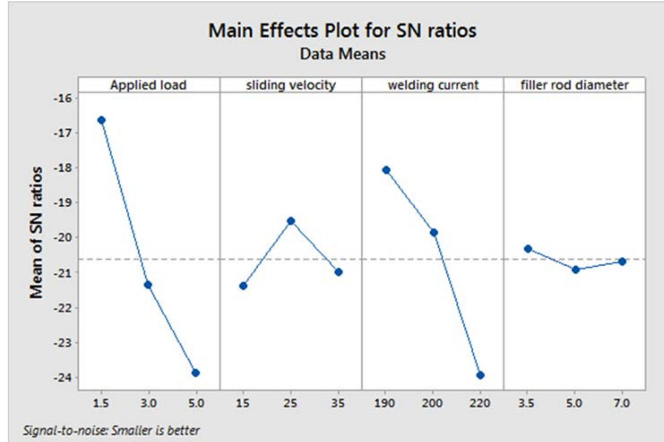

Fig1: Response S/N ratio graph for Wear test

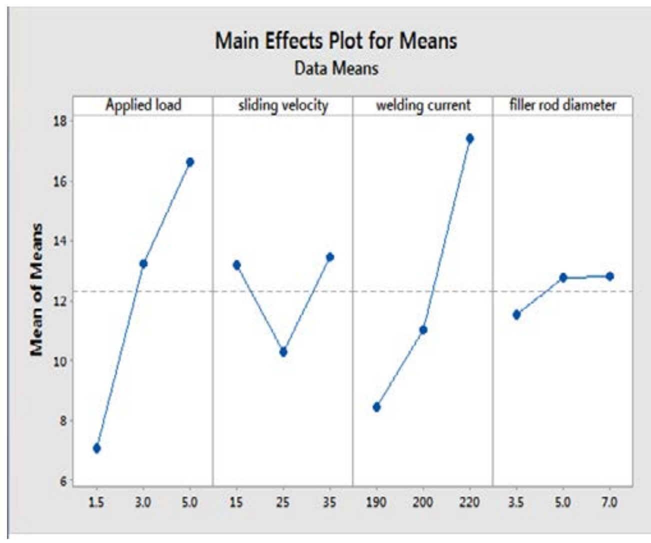

Fig2: Response Mean graph for wear test

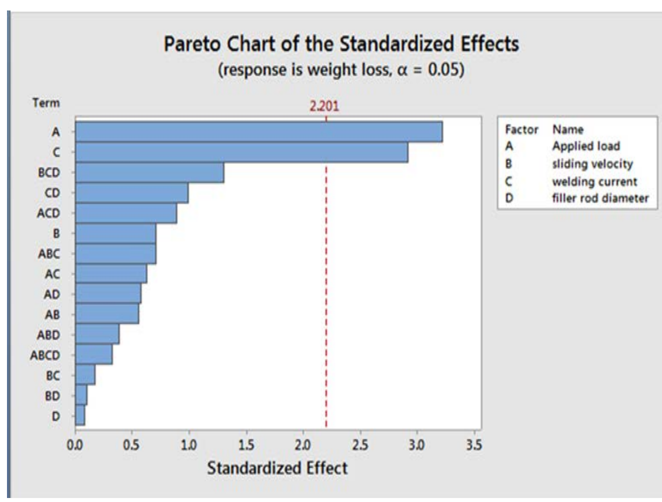

Fig3: Pareto chart for weight loss or wear loss

Optimization test:

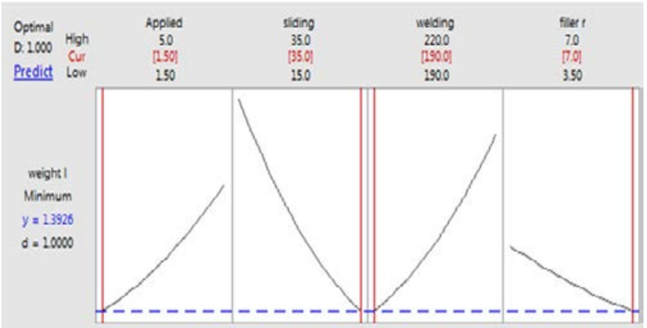

Fig4: Optimum value for wear loss

Table: The optimal set of factors for wear test

S no.	Parameters	Optimum setting
1	Applied Load	1.5
2	Sliding velocity	35
3	welding current	190
4	Filler rod Diameter	7

Results of Hardness test:

Table: Hardness values of specimen(s)

Specimen No.	Hardness Value (BHN)
1	484
2	474
3	475
4	482
5	473
6	451
7	491

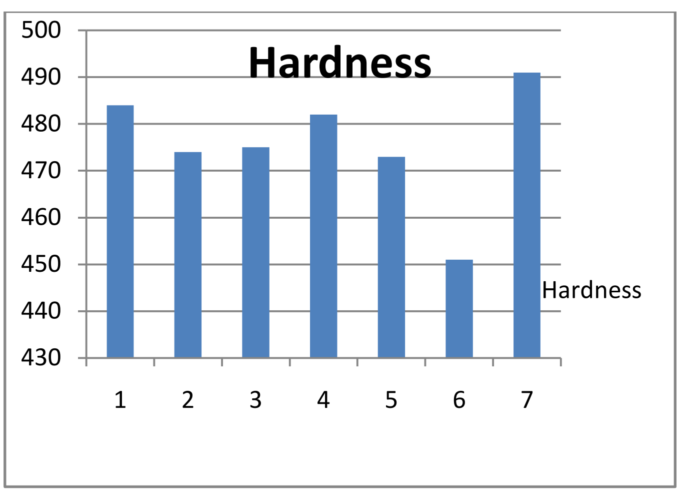

Figure: Hardness values

For the above figure it can be observed that specimen no. 7 has a high hardness value (491 BHN) as compare to other specimens it is more wear resistant and this is also proved from figure. This bar chart shows that high hardness value has also good wear resistance property.

IV. CONCLUSIONS

The Taguchi method is found to be effective for study of effect of variables on the wear resistance. The applied load has maximum effect on wear followed by welding current, sliding velocity and filler rod diameter. In respect of wear characterization using average response of S/N ratio it is inferred that, the optimum set of parameters are A3, B3, C3 and D1 at optimum conditions of applied pressure (1.5Kgs.), Sliding Velocity (20 mm/minute), Welding current (210A) and type of Filler rod diameter (6.5mm). With the above set parameters, minimum weight loss is 4 mg. It is found that specimen 8 shows highest value of hardness with value of current (190A) and low value of Filler Rod diameter which means it is more resistant to wear.

The filler rod diameter shows that rod diameter has less effect as shown in table 16 on wear resistance as compared to the other parameters.

V. FUTURE WORK

Further scope under this topic is given below:

1. The effect of hard facing parameters on the microstructure of specimen(s) can be studied.
2. The effect of stringer beads can be considered for investigation.
3. MIG welding can be used for hard facing, as speed of filler rod can be controlled.
4. Post weld heat treatment effects on hardness and wear can be investigated.

REFERENCES

[1] Bayhan,Yilmaz,2006,"Reduction of wear via Hardfacing of chisel ploughshare",Tribology International, 39, pp. 570–574.

[2] Surface Wear – Analysis, Treatment, and Prevention: R. Chattopadhyay, published by ASM-International, Materials Park, OH, 2001, ISBN 0-87170-702-0.

[3] Kumari, P.; Archna, K. and Parmar, R.S., 2010, "Effect of Welding Parameters on Weld Bead Geometry in MIG Welding of Low Carbon Steel", International Journal of Applied Engineering Research, vol. 6, no. 2, pp. 249–258.

[4] Robert H. Thurston, A treatise on friction and lost work in machinery and millwork, John Wiley&Sons, New York, 1894, fifth edition.

[5] Spuzic, S.; Zec M.; Abhary, K.; Ghomaschi, R. and I. Reid, 1997, “Fractional design of experiments applied to wear simulation”, Journal of Wear, 212, pp. 131–139.

[6] Coronado, John J.; Caicedo, Holman F. and Gómez, Adolfo L., 2009, “The effects of welding processes on abrasive wear resistance for hard facing deposits”, Tribology International, vol. 42, no.5, pp. 745-749.

[7] Valves manuals, edition 2010.

[8] http://www.isixsigma.com/methodology/robust-design-taguchi-method/introduction-robust- design-taguchi-method/.

[9] Mitchell, Luke (November 2012). Ward, Jacob, ed. "The Fiction of Nonfriction". *Popular Science*. No. 5 281 (November 2012): 40..

[10] Roy R.K., “A primer on the Taguchi method”. Competitive manufacturing series, 1990, Van Nistrand Reinhold, New York.

[11] Horvata, Z.; Filipovicb, D.; Kosuticb, S. and Emertc, R., 2008, “Reduction of mould board plough share wear by a combination technique of hardfacing”, Tribology International 41, pp. 778–782.

[12] Zum Gahr, Karl-Heinz (1987). Microstructure and Wear of Materials. Tribology Series, 10. Elsevier. ISBN 0-444-42754-6.

[13] http://www.stoneleigh-eng.com/knifevalve.html

[14] Fluid Power, Naval Education and Training Command, NAVETRA 12964, July 1990, 0502-LP-213-2300

[15] http://www.tpub.com/content/engine/14105/css/14105_87.htm

[13] Katsich, C.; Badisch, E.; Roy, Manish; Heath, G.R. and Franek, F., 2009, “Erosive wear of hardfaced Fe–Cr–C alloys at elevated temperature”, Wear, vol. 267, pp. 1856–1864.

[14] Kirchgaßner, M.; Badisch E. and Franek, F., 2008, “Behaviour of iron-based hard facing alloys under abrasion and impact”, Wear, vol. 265, pp. 772–779.

[15] Klimpel, A.; Dobrza´nski, L.A.; Janicki, D. and Lisiecki, A., 2005, “Abrasion resistance of GMA metal cored wires surfaced deposits”, Journal of Materials Processing Technology, 164– 165, pp. 1056–1061.

[16] http://www.Stellite1.com.

[17] http://nutek-us.com/wp-txt.html.

[18] Srivastava, S.K.,“Tribology in Industeries”,S.Chand & Company Ltd., New Delhi, 2001.

[19] Ringsberg, Jonas W.; Skyttebo, Anders and Josefson, l. B. Lennart, 2005, “Investigation of the rolling contact fatigue resistance of laser cladded twin-disc specimens: FE simulation of laser cladding, grinding and a twin-disc test”, International Journal of Fatigue, 27, pp. 702–714.

[20] Singla, Manoj; Singh, Dharminder and Deepak, Dharmpal, 2010, “Parametric Optimization of Gas Metal Arc Welding Processes by Using Factorial Design Approach”, Journal of Minerals & Materials Characterization & Engineering, vol. 9, no.4, pp.353-363.

[21] Chang, Chia-Ming; Chen, Yen-Chun and Weite, Wu, 2010, “Micro structural and abrasive characteristics of high carbon Fe–Cr–C Hard facing alloy”, Tribology International, vol. 43, pp. 929–934.