IMPROVING WEAR RESISTANCE OF PISTON DIE THROUGH HARDFACING

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Abstract

In the present study an effort has been made to improve wear resistance of piston die through hardfacing by using different electrodes. Hardfacing is a process in which a layer of material with high mechanical strength and wear resistance is deposited on the substrate material generally by using welding process. The material deposited generally possess high hardness, which increase the wear resistance and corrosion resistance at room temperature as well as at elevated temperature. In the current investigation three different iron based electrodes E310, E316 and E410 having different chromium percentage were chosen for hardfacing having three different diameter range 2.4 mm, 3.2 mm and 4.0 mm. The investigation has been done on the samples (H13 die steel base/substrate material) prepared by these electrodes using three welding current 140A, 160A and 180A. Wear test, Hardness test and microstructure investigations of hardfacing layers were carried out for investigating the effect of hardfacing on mechanical properties. It was found that the welding electrodes (chromium percentage) have large affect on wear resistance property, then welding current and welding electrode diameter. Good wear resistance is observed at combination of high value chromium percentage electrode and low value welding current & 3.2 mm electrode diameter.
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Keywords: *Hardfacing, Wear Rate, Hardness, Microstructure.*

1. Introduction

Wear of mechanical parts are generally fail due to wear, which is one of the most common problems faced in the manufacturing industry and automotive industries. Mechanical parts often fail not because they rupture, but generally because of wear, which results into change in the dimensions and fitting of parts. In the last few decades researching is going on to improve the life of mechanical parts by either chaging the bulk material or by putting a layer of superior material on the surface. The concept of depositing a layer on the surface is more economical and appropriate as compare to changing the entire component material because changing the whole material result into more cost and time consumption [1-5]. Hardfacing, is the process in which welding is used to build-up of deposits of specialized materials to resist abrasion, or impact at room and high temperature. Hardfacing is used in many applications such as agriculture equipment's, mining tools etc. in order to improve the surface properties such as hardness. In hardfacing generally alloy is deposited on the soft material, which is generally made from low or medium carbon steel by using a welding method in order to improve the wear resistance and hardness [6]. Many welding methods such as oxyacetylene gas welding, gas metal arc welding, shielded metal arc welding (SMAW) and submerged arc welding can be used for hardfacing. The most important differences among these techniques lie in the welding efficiency, the weld plate dilution and the manufacturing cost of welding consumables [5, 7]. SMAW is mostly preferred owing to the its cost effectiveness and easy to use [6].

The carbides are generally very hard, and addition of these carbides into the surface layer resulted into increase in the abrasion resistance, so preferred for those applications where parts are subject to high surface friction. Hardfacing deposition is one of the popular techniques used to improve the hardness, hence abrasion resistance by introducing a high carbide content at the required surfaces of mechanical parts, so making efficient use of usually high cost alloys [8]. Buchely et al. [6] investigated & compared the abrasion resistance of hardfacing alloys reinforced with primary chromium carbides and tungsten carbides on A36 carbon steel by using shielded metal arc welding. The results indicated that the wear resistance depends on the size, shape, distribution and chemical composition of the carbides, as well as by the matrix microstructure. Jones and Roffey [2] investigated hard facing coatings for ground engaging applications by the addition of tungsten carbide. In this experiment WC powders of various sizes were added at different levels and the results were characterized in terms of physical properties, microstructure and wear resistance. The result indicated that improvement in wear resistance due to the presence of the WC was significant. Kumari et al. [9] used automatic gas metal arc welding (GMAW) for depositing MW1 on IS2062. The welding parameters such as welding speed, voltage and gas flow rate were varied to see the effect on weld bead geometry like penetration. The result indicated that the arc voltage, welding speed has remarkable effect on the bead geometry parameters but gas flow rate does not have much effect on them. Kocher et al. [10] used EN31 as a substrate material and applied MR 3LH electrode coatings to increase the wear resistance. The wear surfaces were evaluated by SEM and wear test were performed on pin on disc setup. The result indicated that the wear resistance of hardfaced sample was improved than unprocessed samples.

In this presented paper, the Manual Metal Arc Welding for surface modification, to improve the wear resistance of piston die has been used. The H13 die steel base material is hardfaced with three different types of iron based electrodes (E310, E316 and E410) having different chromium % and were investigated with regard to their wear and hardness.

2 Experimental Details

2.1 Selection of base metal and electrode

H13 Die steel was used as a substrate (base metal) for hardfacing. H13 has good thermal shock, high hardenability & excellent wear resistance. The chemical composition of Base metal is given in table 1.

Table 1: Chemical composition of base metal

Carbon	0.44 %
Manganese	0.45 %
Phosphorous	0.009 %
Sulphur	0.015 %
Silicon	0.90 %
Vanadium	0.82 %
Molyvadnium	1.46 %
Cromoium	5.20 %
Iron	Balance

Welding Electrodes E310, E316 & E410 of cylindrical in shape were used for hardfacing. The diameters of welding electrodes were 2.4mm, 3.2 mm & 4.0mm. The chemical compositions of electrodes are given in table 2.

Table 2: Chemical Composition of Welding Electrodes

Composition	E310 (E1)	E316 (E2)	E410 (E3)
Carbon	0.11	0.04	0.09
Manganese	1.90	0.9	0.55
Silicon	0.52	0.39	0.30
Chromium	26.2	19.2	12.3
Nickel	20.95	12.1	0.45
Sulfur	0.012	0.020	0.010
Phosphorus	0.016	0.020	0.020
Iron	Balance	Balance	Balance

2.3 Welding Machine

Welding machine of Panasonic made, model YC200BL3 fully digital DC welding machine & which is capable of welding up to 200A was used for hardfacing as shown in Fig. 1. It has full digital control, which allows easy settings & easy to operate.

Fig.1. Welding Machine

2.4 Mathematical Model

Taguchi Approach was used for study of effect of parameters on the wear resistance and hardness. L9 orthogonal array was used to study the effect of three parameters at three levels. The L9 orthogonal array used to study the effect of process parameters is shown in table 3.

Table 3 L9 Orthogonal Array

Experiment Number	Parameters		
	Welding Electrode	Welding Current	Electrode Diameter
1	E1	140A	2.4 mm
2	E1	160A	3.2 mm
3	E1	180A	4.0 mm
4	E2	140A	3.2 mm
5	E2	160A	4.0 mm
6	E2	180A	2.4 mm
7	E3	140A	4.0 mm
8	E3	160A	2.4 mm
9	E3	180A	3.2 mm

2.5 Testing of samples

Three tests was conducted after hardfacing the specimens. These are given below:-

1. Wear test

2. Hardness test using Brinell hardness tester.

2.5.1 Wear test on Pin on Disc

Wear test was conducted on pin on disc machine as shown in Fig. 2. Wear readings were taken for each specimen for an interval of 15 min for fixed applied load of 500 gram at a fixed wheel speed of 180 rpm. The size of specimen used for wear test was 10x10x50 mm.

Fig. 2 Pin On Disc Machine

Each specimen weight was measured before & after the wear test. For measuring the weight accurately electronic weighing machine was used, capable of measuring weight up to 0.1 milligram (0.0001 gram). We calculated the average wear rate by doing two trials for each sample. The difference between the weight before wear test and after wear test is the wear rate.

2.5.2 Hardness test on Brinell hardness tester

Hardness parameter was also measured for each specimen. Brinell hardness tester was used for measuring the hardness as shown in Fig. 4. Work piece was placed on bed provided & load was provided by rotating the handle till a beep sound was observed for indentation. Reading of the hardness was measured directly from the scale.

Fig.4. Brinell Hardness Tester

3 Results and Discussion

3.1 Wear Test

Wear rate was calculated by measuring weight difference before and after wear test. Effects of welding electrode, welding current and electrode diameter on wear resistance are shown in Fig. 6, 7 & 8 respectively. As shown in Fig. 6 the wear loss is minimum for E1 type electrode and maximum for E3 type electrode. The wear loss for E1 types electrode is 0.023 gm, whereas for E3 type its 054 gm. Fig. 7 shows that the wear loss is minimum for 140A current and maximum for 160A current. Fig. 8 shows that the wear loss is minimum for 3.2 mm diameter electrode and maximum for 4 mm electrode.

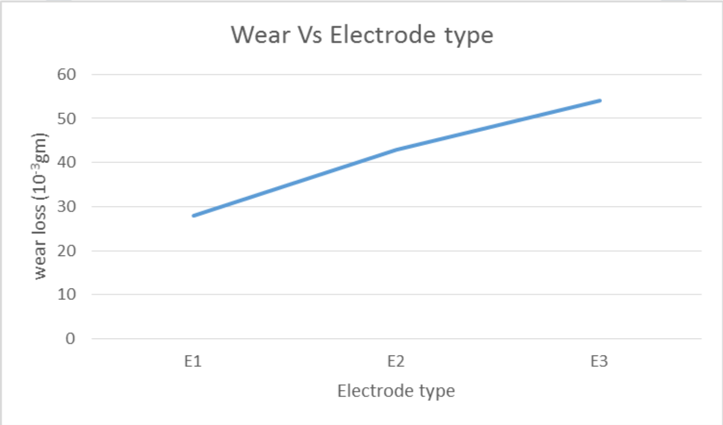

Fig.6 Effect of welding electrode on wear resistance

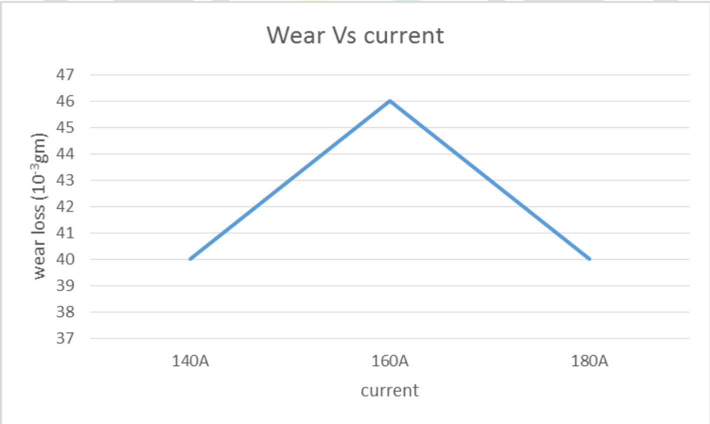

Fig. 7 Effect of welding current on wear resistance

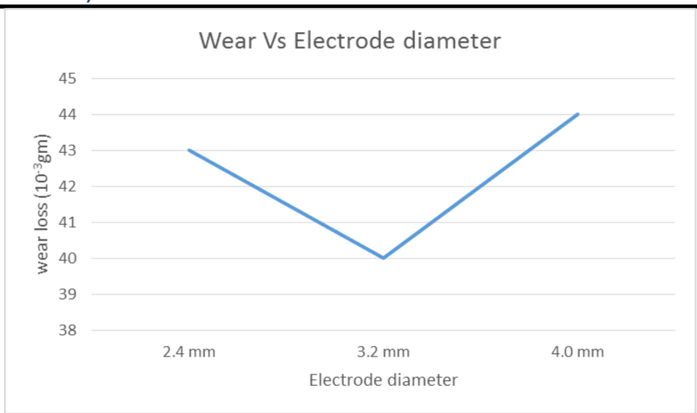

Fig.8 Effect of electrode diameter on wear resistance

Figures shows that electrode E1 (chromium percentage up to 26.2%) has good wear resistance at welding current 140A with 3.2 mm diameter electrode.

3.2 Hardness Test

The hardness was measured in BHN or HB for each specimen & average of these values are taken for analysis. Effects of welding electrode, welding current and electrode diameter on hardness are shown in Fig. 9, 10 & 11 respectively. The hardness for hardfacing with E1 type electrode is maximum and its value is 191 HRB, where as its minimum for E3 type electrode and its value is 173 HRB as shown in Fig. 9. The hardness is maximum at 180A current and its minimum at 160 A current as shown in Fig. 10. The hardness value is almost same at electrode diameter 2.4 mm and 3.2 mm, whereas its minimum at 4 mm diameter.

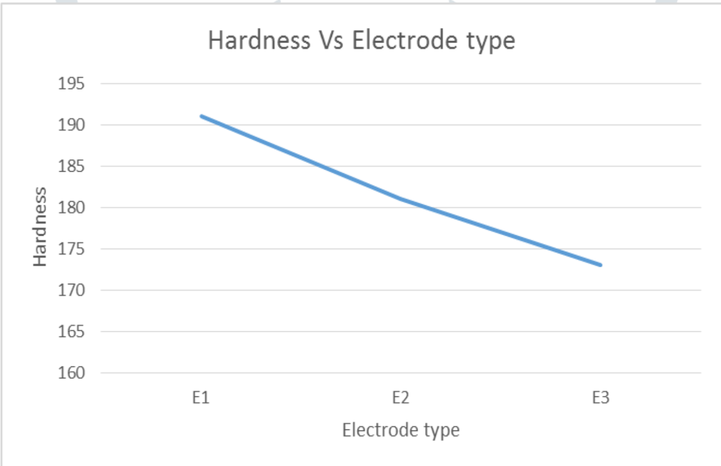

Fig. 9 Effect of welding electrode on hardness

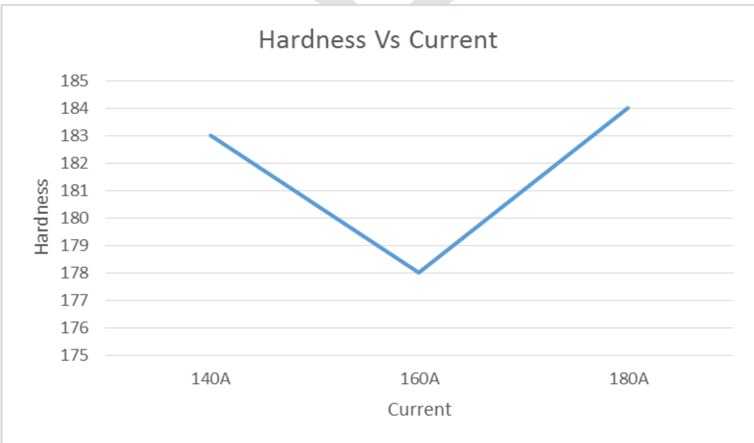

Fig. 10 Effect of welding current on hardness

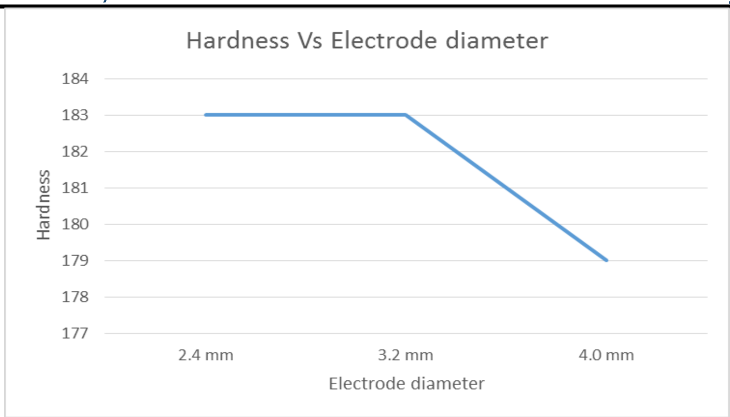

Fig.11 Effect of electrode diameter on hardness

Figures shows that electrode E1 (chromium percentage up to 26.2%) shows good hardness at welding current 180A with 2.4 mm diameter electrode.

4 Conclusions

The conclusion of present research is summarized as follow:-

1. Welding electrode chromium percentage has large effect on wear resistance, then welding current and electrode diameter has minimum effect on wear resistance.
2. The maximum wear resistance is observed at combination of high chromium percentage electrode and low value of welding current and welding electrode.
3. The maximum hardness is observed at combination of high chromium percentage electrode and low value of welding current and welding electrode.
4. The optimized welding parameters for good wear resistance are E310 electrode (chromium percentage up to 26.2%), 140 A welding current & 2.4mm welding electrode diameter.
5. Welding electrode diameter has less effect on wear resistance and hardness.
6. Wear resistance increases with increase in hardness.

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