A REVIEW PAPER ON RESEARCH WORK DONE IN HARDFACING

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ABSTRACT

Wear is the biggest factor that controls the performance and life of any machine part. The interaction between functional surfaces in their relative motion causes adverse effects in the surface layers, leading to their deterioration. Most worn parts don't fail from a single mode of wear, but from a combination of modes, such as abrasion and erosion etc. Research is going on over years to reduce the wear either in the form of using a new wear resistant material or by improving the wear resistance of the existing material by the addition of any wear resistant alloying elements. According to researchers hardfacing is the best method for overcoming wear problems of machine parts as it increases the life of machine part and also protects from damage. We can use many types of hardfacing alloys according to requirement, which may be cheap or costly. In this paper an attempt has been made to review the work of some researchers who conducted the experimental studies on different wear resistant hardfacing alloys, which are employed on the substrate surface of material by different welding processes.

Keywords: Hardfacing, welding, weld consumables, hardfacing coatings, wear resistance alloys, abrasive wear.

1.INTRODUCTION

In Industries machine parts are deteriorate and fracture early from their intended life not because of poor operation but because of wear and abrasion. In agricultural tools and earthmoving equipments the problem is same, so this problem is present at all places where the tools have to work on the hard surfaces of materials. Different categories of wear exist, but the most typical modes are – Abrasion, Impact, Metallic (metal to metal), Heat, Corrosion etc. Most worn parts don't fail from a single mode of wear, such as impact, but from a combination of modes, such as abrasion and impact etc. This problem can be overcome by applying surfacing techniques and the best method is Hardfacing.

Hardfacing is a commonly employed method to improve surface properties of tools in which an alloy is homogeneously deposited onto the surface of a base material by different techniques of welding, with the purpose of increasing hardness and wear resistance .[3] A wide variety of hardfacing alloys is commercially available for protection against wear, so proper material selection becomes difficult. Selection of the material should be on the basis of finished hardness, microstructure, mechanical properties and wear resistance of a particular type of steel. Hardfacing may be applied to a new part during its production, or it may be used to restore a worn-down surface. Hardfacing increases the service life of a part and there by extend the lifetime of machinery equipment efficiently.

2.HARDFACING PROCESSES

For applying hardfacing generally welding process is used, it is also better from other processes as it can be suitable for almost all alloys. The other methods for applying hardfacing are Thermal spraying and Cladding.

Thermal spraying processes are preferred for applications requiring thin, hard coatings applied with minimal thermal distortion of the work piece and with good process control while Cladding processes are used to bond bulk materials in foil, sheet or plate form to the substrate to provide triboligical properties. The cladding processes are used either where coatings by thermal spraying and welding cannot be applied or for applications which require surfaces with bulk like properties.[4]

Welding processes is generally used for hardfacing because it provides high bond strength; welding processes most commonly use the coating material in the rod or wire form. Thus materials that can be easily cast in rods or drawn into wire are commonly deposited. Welding process is better for hardfacing different alloys which is not possible by other two processes.[2]

The welding processes which are used for hardfacing are Submerged metal arc welding, Gas metal arc welding and Plasma welding. SMAW is the most common and versatile process, although it does not provide the highest deposition rate. The rate of dilution depends on materials and on the welder's skill.[4]

3.SOME RESEARCH STUDIES RELATED TO HARD FACING:

Research is going on in the area of hardfacing using various processes and different consumables and different base metals .Most of the research is carried out studying the wear characterization, as the basic aim of hardfacing is to improve or extend the life of various components used across the industry owing to high cost of replacement of original part. Some researches on hardfacing are given below

Augustin gualco, 2013 [1] studied the microstructural evolution and wear resistance of a nanostructured iron-based alloy which is deposited by using FCAW welding process and found that the wear resistance was higher for the specimen welded with two layers. The hardness decreased with the second layer from 920 to 800 HV, for extreme values.

G.R.C. Pradeep, 2013 [2] done the hardfacing of AISI 1020 steel by using three different welding processes (TIG welding, Arc welding and Gas welding) and in research he found that TIG welding samples were showing better wear properties until a sliding velocity of 1.256 m/s with various sliding distances and loads, compared to Gas welding samples and Arc welding samples. Gas Welding samples and Arc Welding samples yielded better wear properties at higher sliding velocities above 1.571 m/s with various sliding distances and various loads compared to TIG Welded Samples.

Xinhong Wang, 2008 [3] studied the effect of addition of alloy elements on the Iron based hardfacing layer and also the effect on wear properties of hardfacing layer. He found in the research that the hardfacing layer produced by Fe–Ti–V–Mo–C hardfacing materials possess much higher wear resistance and a lower friction coefficient. The hardness and wear resistance of the hardfacing layer increases with increasing of Fe–Ti, Fe–V, Fe–Mo and graphite.

Harvinder Singh, 2014 [4] studied the effect of different compositions of iron based hardfacing electrodes on stainless steel. The three different hardfacing alloys are Hard Alloy 400, Hardloy III and Hardloy V. He uses SMAW welding process for depositing hardfacing layer and in the research he found that the hardness values can be enhanced by approximately 1.7 times using Hard Alloy 400 hardfacing electrode, 2 times by using Hardloy III hardfacing electrode and 2.4 times by using Hardloy V hardfacing electrode.

S. Chatterjee, 2003 [5] done research by using different hardfacing electrodes & weld procedures and by varying the electrodes he studied its effect on abrasion resistance of the hardfacing deposit. In the research he found that by using different hardfacing electrodes as well as weld procedures using similar electrode results in wide variation in low stress abrasion resistance.

S.G. Sapate, 2006 [6] performed erosion tests on five different grades of high chromium iron weld hardfacing alloys to determine hardness of erodent particles and ability of erodent particle to cause gross fracture of the carbides. In the research he found that the erosion rate of weld hardfacing high chromium cast iron alloys can be rationalised in terms of relative hardness of the erodent particles under given erosion conditions. Significant differences were seen in ranking of weld hardfacing alloys depending upon erodent particle properties and the impingement angle.

Z. Horvat,2008 [7] compared the wear of regular mouldboard plough shares with the hardfaced mouldboard by using two different welding processes SMAW and Induction welding process. In the research he found that the weight losses were lower for both types of hard faced plough shares as compared to standard shares, but the differences were not significant. Lower fuel consumption and a higher rate of work in ploughing were achieved with hard faced plough shares as compared to regular shares.

A. Zikin [8] uses two different hardfacing materials and investigates erosive and abrasive wear behaviour of TiC–NiMo and Cr3C2–Ni reinforced NiCrBSi hardfacings at temperatures upto700 C. In the research he found that for hardfacings under consideration the significant decrease in hardness is observed in the temperature interval between 700 C and 800 C.

John J. Coronado[9] perform hardfacing operation by using two different welding processes, SMAW and FCAW and evaluate the deposits for wear resistance properties. In the research work he found that hardfacing using FCAW presents higher abrasive wear resistance than hardfacing by SMAW process.

Patrick W. Leech [10] compared the abrasive wear of hardfacing deposits of a complex high alloy (SHS9290) and a tungsten carbide–Ni based metal matrix composite. He uses SMAW welding process for hardfacing, he found that SHS9290 alloy has shown a significantly lower wear rate than the WC–Ni based MMC during both running-in and steady state stages in the dry sand rubber wheel tests and pin-on-flat tests using garnet abrasive.

S.G. Sapate [11] studied the effect of carbide volume fraction on erosive wear behaviour of hardfacing cast irons. He used FCAW welding process for hardfacing. In the research he concluded that the erosion rates of weld hardfacing cast irons showed quite different trends depending on erodent particle hardness and the erosion conditions. Under mild erosion conditions, erosion rate decreased with increasing CVF in case of all the erodent particles.

M.F. Buchely [12] compared the microstructure and abrasion resistance of hardfacing alloys reinforced with primary chromium carbides, complex carbides or tungsten carbides. He has done the hardfacing by using the SMAW process; he uses three different commercial electrodes. He concluded in his research that three-layer complex carbide deposits showed the best abrasive wear resistance of all the tested hardfacing alloys.

Kwon-Yeong Lee [13] uses Fe-base Co-free hardfacing alloy and done the hardfacing by using Gas tungsten arc welding process. In his research he compared Fe-base Co-free hardfacing alloy to Fe-base NOREM 02 in the temperatures ranging from 300 to 575K in pressurized water. He found in his research that the wear resistance of Fe–Cr–C–Si was equivalent to that of Stellite 6 up to 575 K. The weight loss of Fe–Cr–C–Si after 100 cycles of sliding wear was very small and was not significantly affected by test temperature. However, the weight loss of Fe–Cr–C–Si increased almost linearly with increasing temperature up to 575K after 1000 cycles.

V.E. Buchanan [14] uses Fe-Cr-C hardfacing alloy and done hardfacing by using SMAW process, Hypereutectic and hypoeutectic studies were carried out by him using optical and SEM techniques. In his study he found that the mass loss of the hardfacings increased linearly with sliding distance in both dry and slurry conditions. However, the wear rate was not always directly proportional to load; the hypereutectic coating exhibited a transition from low to high wear coefficient when the higher loads were applied, which was due to severe fracturing of the primary carbides.

M. Kirchgaßner [15] evaluates the wear behaviour for pure abrasion and for combined wear of iron-based hardfacing alloys. He uses Fe-Cr-C-Nb hardfacing alloy and uses GMAW process for hardfacing, he found that under erosive wear or high impact loads, the tungsten carbide-containing hardfacing alloy underperforms significantly compared to FeCrCNb alloys provide reasonably good behaviour under all test conditions .

Ji Hui Kim [16] uses Fe–Cr–C–Si–B hardfacing alloys and in his research the effect of boron on the abrasive wear behaviour of the austenitic Fe–Cr–C–Si–B hardfacing alloys was investigated with varying boron concentration. In his research he found that the abrasive wear resistance of austenitic Fe–20Cr–2.4C– 1.0Si–*x*B with varying boron concentration improved as increasing boron concentration up to 0.6 wt.%. At 0.6 wt. % boron concentration, the primary borides were started to precipitate and these precipitates resulted in an improvement of the abrasive wear resistance.

F. Fernandes [17] studied the influence of the addition of nanostructured zirconia particles on the microstructure, micro-hardness and wear performance of a Ni-based alloy. He uses nanostructure zirconia particles for hardfacing. He found that the hardness and wear behaviour of coatings was improved with nanostructured zirconia additions while the friction coefficient is decreased. The nanostructured ZrO2 coating shows the highest hardness values but also the highest specific wear rate.

B.K. Sreedhar [18] used two different hard faced coatings Co-based Stellite 6s alloy coatings and Ni-based Colmonoy 5s coatings for hardfacing and the results compared with that 316L austenitic stainless steel. In his study he found that cavitation resistance of both Stellite6 and Colmonoy5 deposits are significantly higher than that of 316L austenitic stainless steels in sodium. This confirms that hardfacing of the surfaces by any of these alloys can considerably reduce the extent of damage expected in components in FBRs which are likely to undergo cavitation in service.

Jun-Ki Kim [19] uses GTAW process for NOREM 02 hardfacing alloy and the sliding wear behaviour of an iron-base NOREM 02 hardfacing alloy was investigated in the temperature range of 25–3008C under a contact stress of 103 MPa. In his study he found that the wear resistance of NOREM 02 under the contact stress of 103 MPa was nearly equivalent to that of Stellite 6 in the temperature range below 180 C. With a further increase of temperature, the wear mode of NOREM 02 changed abruptly to severe adhesive wear at 190 C and galling occurred above 200 C.

Novana Hutasoit [20] uses the laser cladding process for hardfacing the Stellite 6 (Co base) and Deloro 40G (Ni base). Fatigue life study of structures constructed by Stellite 6 (Co base) and Deloro 40G (Ni base) hardfacing alloys were conducted using rotary bending fatigue test. He found that the specimen constructed by laser clad Stellite 6 (Co base) and Deloro 40G (Ni base) on AISI 4130 steel to a certain size showed decrease in fatigue life compared to specimen of the same size without cladding, due to the presence of tensile residual stress in coating area of laser clad specimen.

X.H. Wang [21] uses Fe-based hardfacing coating reinforced by TiC particles. The microstructure and wear properties of the hardfacing coating were studied by means of scanning electron microscopy (SEM), transmission electron microscopy (TEM), an X-ray diffractometer (XRD) and a wear test. . In his research he found that after adding FeTi, TiO2 and graphite to the fluxes of an electrode, TiC particles are formed by metallurgical reaction during the arc welding. The microstructure and properties of the hardfacing coating is affected by the amount of FeTi, TiO2 and graphite.

Q.Y. Hou [22] uses the nickel-based hard facing alloys and done the hardfacing by Plasma transferred arc welding process. The effects of Mo on the microstructure and wear resistance properties of the nickel-based hard facing alloys were investigated using optical microscopy, scanning electron microscopy and X-ray diffraction. He concluded that the addition of Mo is beneficial to refine the dendrites of (Ni,Fe) solid solution and the morphology for Cr-rich carbides changed from plate-like to net-like which is beneficial to the wear resistance.

Kun-Chao Tsai [23] uses Norem hardfacing alloy and GTAW process for hardfacing. Longitudinal and transverse cracks were observed on the surface of Norem hardfacing welds for a period of time after welding. He found that the cracks of Norem weld were caused by hot cracking, which are due to weld residual stress and lack of ferrites. The misorientation boundaries of columnar inter-dendritic carbides become the easy path for cracks in Norem weld.

Amardeep Singh Kang [24] uses 5HCr, 7.5HCr, 12HCr and 8HCr hard facing alloys and GTAW process for hardfacing. He studied the effect of the hard facings on the extent of wear and the wear characteristics of the tiller blades. He concluded in his research that the minimum wear rate was observed in the case of 12HCr hardfacing alloy. This may be due to the presence of hard chromium carbides. The laboratory and field results revealed that as the percentage of Cr increases, the wear resistance of the corresponding alloy increases.

M. Martínez [25] uses Fe based hardfacing alloys and Flux Cored Arc Welding process for hardfacing. He studied the influence of the pin geometry (flat and spherical) in a POD test on the wear resistance of a weld-deposited hardfacing of H13 steel against low carbon steel AISI 1020 under different load and sliding speed conditions. He concluded that the wear behaviour of both pins showed difference according to each tested condition. Under light load (10H) the flat pin wear more than the spherical, while at heavy loads (40H) it was the opposite.

Janette Brezinová [26] uses hardfacing electrodes E 508 B and E 518 B and SMAW welding process for hardfacing. He performs test to carry out a tribological and metallographical analysis for two types of hardfacing layers. The analysis can contribute to clarification of the relationship between the microstructure and wear resistance of layers. In his research he found that claddings made by electrode E 518 B, in terms of hardness values, appear to be of high quality. It can be concluded that in the optimized chemical composition of weld materials, it is necessary to take the structural constitution of the cladding in to consideration.

R. Chotěborský [27] uses different commercial hardfacing electrodes and GMAW process for hardfacing. He compared the microstructure & abrasion resistance of hard facing alloys reinforced with chromium carbides or complex carbides. In his study he concluded that the hardness of hypoeutectic hardfacings increases with the carbidic eutectic part and type and the abrasive wear rate of hypoeutectic hardfacing depends on the structural components portions. A higher part of alloyed eutectic reduces the wear rate.

4.CONCLUSION

Surface engineering is used for overcoming wear abrasion problems of tools in machining industries and the best method to overcome it is hardfacing. It is the best process to get the desirable surface properties to reduce the cost of replacement and downtime because parts last longer and fewer shutdowns are required to replace them. Hardfacing can be done on approximately any metal using wide variety of welding processes. Different alloying elements can be introduced in to the base metal in the form of weld consumables to achieve any desired property like hardness, porosity, wear and corrosion resistance etc. Surfacing is economical tool which can be used to increase the service life of the components used in various types of industries. Previously this was used to restore the worn parts but now days this technique is also used to make new parts. The success of hardfacing application depends upon the optimized composition of alloying elements and the welding process used for a particular application.

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