Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 6, Issue 02, February -2019

STUDY TO IMPROVE ADHESIVE WEAR RESISTANCE AND HARDNESS OF MILD STEEL USING STELLOY-6 BY GTAW PROCESS

[1]Vikash kumar, [2]Dr. R. K YADAV

[1]M. Tech Research Scholar, Dept Of Mechanical Engineering,
Sant Longowal Institute Of Engineering And Technology Longowal Sangrur Punjab

[2]GUIDE, Associate Professor (Mechanical),
Sant Longowal Institute Of Engineering And Technology Longowal Sangrur Punjab

ABSTRACT:- *Hard facing is a part of surfacing technique that is a process of depositing a layer or layers of some special alloy material on the substrate that are subjected to wear and severe loading conditions. Hard facing alloys are selected on the basis of required application of strengthen material. Shielded metal arc welding, Submersed arc Welding process , Gas metall arc welding is the most commonly used hard facing process because of its versatility of operation and easy availability. Mild Steel steel has been selected as the substrate material because of its low wear characteristics and wide industrial application. In the present work a detailed study has been carried out to investigate the ADHESIVE WEAR RESISTANCE AND HARDNESS OF MILD STEEL USING STELLOY-6BY GTAW PROCESS Total 3 samples made to investigate the wear characteristics, metallurgical characteristics, macro structural, dilution and spectral analysis. It was found that as no. of layers increased, there was a change in microstructure due to the variation in chemical compositions which resulted to increase in hardness. It also concluded that increase in no. of layers resulted to increase in reinforcement and decrease in dilution percentage .The best wear behavior was observed in sample B with minimum wear rate of 0.0612 g/hr. The 2nd layer of sample B showed maximum percentage of carbon or carbide formation which resulted to produce a matrix phase of martensitic and retainedaustenitic structure. All the results were explained in detail in the work.*

Keywords: *Multilayer hardfacing, GMAW, Adhesive wear, Pin on disc, Metallurgical characterization, ASTM A36, Wear mechanism*

1. INTRODUCTION

The stability and reliability of any material is invaluable for any nation especially developing countries like India. Despite being in the manufacturing / assemblies or service sector, all types of industrial setup closed late and made their reputation with the stability and reliability of their products. Deficiency of the material by wearing and corrosion is a great loss, whether it is of prestige or economic loss. Although researchers have already given considerable attention to developing and controlling the modern techniques and methods and to handle and control the problems of war, yet they have done more research to reduce the harm caused by them. the wanted. It is estimated that using better techniques to control wear and corrosion can be reduced by 30% of the cost related to wear and corrosion. These wear and corrosion related problems can be reduced mainly in two ways:
By using high cost wear and corrosion resistant alloys compared to existing low cost ones.
By improving the wear and corrosion resistance of existing metals and alloys by making some amendments in the surface.
Since the wear surface is phenomenon and most external mating is on the surface, it is more suitable and economical to use the method after the surface modification compared to the previous, which would involve a lot of cost of operation but in it More time will also be involved. Compared to the second technique. In recent times, various commercially viable surface-coating techniques, thermal spraying, chemical vapor deposition and physical vapor deposition methods have been considered.

1.2WEAR

It is the phenomenon of the removal of material from a solid surface as a result of sliding action. This constitutes the main reason why the artifacts of society (automobiles, washing machines, tape recorders cameras, and clothing) become useless and have to be replaced. From tribological considerations, wear is the most important reason amongst the friction, wear and lubrication.

1.2.1Factors affecting wear

The main factors affecting wear are:

@IJAERD-2019, All rights Reserved

1. Design
2. Applied load
3. Contact area and degree of movement
4. Lubrication
5. Environment
6. Material properties (surface finish, hardness and microstructure)

Design tolerance should be given adequate sanction. The contact load should be kept minimal on the sliding components, while the contact area should be maximized.

In this situation, lubrication plays an important role and the design should ensure that adequate lubrication of components in relative motion can be effectively distributed. The finishing of the components of the surface is highly valued in the form of highly polished (<0.25 mm r) or very rough (> 1.5 mm r) surfaces to increase the tendency to wear and grow. Smooth surfaces result in more contact. Small ties 'valleys' and 'asperities' on the smooth surface mean that lubricants can not be placed in place between the surfaces and the dislikes are kept in close contact with surfaces as a result of wearing the material. Acne is interlocking as a result of hard surfaces, which promotes severe tearing bile. The surface finishes are so better among these extremes.

However, some other factors can be said in the reasons or sources of wear, although some of these may be re-components. Generally, there are two sources of wear; Primary and secondary [19], which can be further divided as shown in table 1.1.

Table 1.1: Causes of wear

Cause of primary wear	**Cause of secondary wear**
Friction	Erosion
Impact	Corrosive
Adhesive	Heat
Adhesive	

It is not universally true that increase in friction cause increase in wear. There may be some stray exceptions to this. One such example is “E.P. Lubrication” when friction is low but wear is fairly high (because of aggressiveness of friction reducing agents on metal surfaces etc.) or friction is high or wear is low (because of effective separating film of relatively high strength). There may be some other sources/causes like vibration, cavitations and environmental attack etc.

1.2.2 Different types of wear

The wear can be categorized into different types based on the source/causes of wear mentioned earlier. The wear, encountered in industrial situations, can broadly be divided into following types and a rough share of each type of wear[19], as a percentage of all the wears taken together, is against each type as shown in Table 1.2.

Table 1.2: Different types of wear

Types of wear	**Percentage**
Adhesive wear	50
Adhesive wear	15
Erosive wear	8
Fretting wear	8
Corrosive wear	5
Others	14

1.2.3 Adhesive wear

The action of one material sliding over another with surface interaction and welding (adhesion) on localized contact. Adhesive wear generally describes wear due to the sliding action between two metallic components where no adhesives are intended to be present. When the applied load sufficiently low, an oxide film usually generated as a result of frictional heating accompanied by sliding. The oxide film prevents the formation of a metallic bond between the sliding surfaces, resulting in low wear rates. This form of wear is called oxidative or mild. If the applied load is high, formation of a metallic bond occurs between the surfaces of mating materials. The resulting wear rates are extremely high. This form of wear is called severe or metallic wear. Another form of wear, called galling, is a special form of severe adhesive wear. Galling occurs if the wear debris is larger than the clearance and if seizure of the moving component results. Frequently, only small amounts of sliding result in galling and subsequent failure of a component.

Generally, Adhesive wear occurs when two bodies slide over or are passed into each other, which promote material transfer. This can be described as plastic deformation of very small fragments within the surface layers. The asperities or microscopic high points or surfaces roughness found on each surface, define the severity on how fragments of oxides are pulled off, and

@IJAERD-2019, All rights Reserved

add to the other surface. As we know, strong adhesive force sets up when the atoms from two materials come into intimate contact. During sliding, a small patch of the surfaces comes into intimate contact with a small patch of other surface and if this bond is strong, this contact is broken. This breakage is usually not of the interface of the two patches; however it takes place from within one of the materials depending upon the bond strength. This is known as adhesive wear.

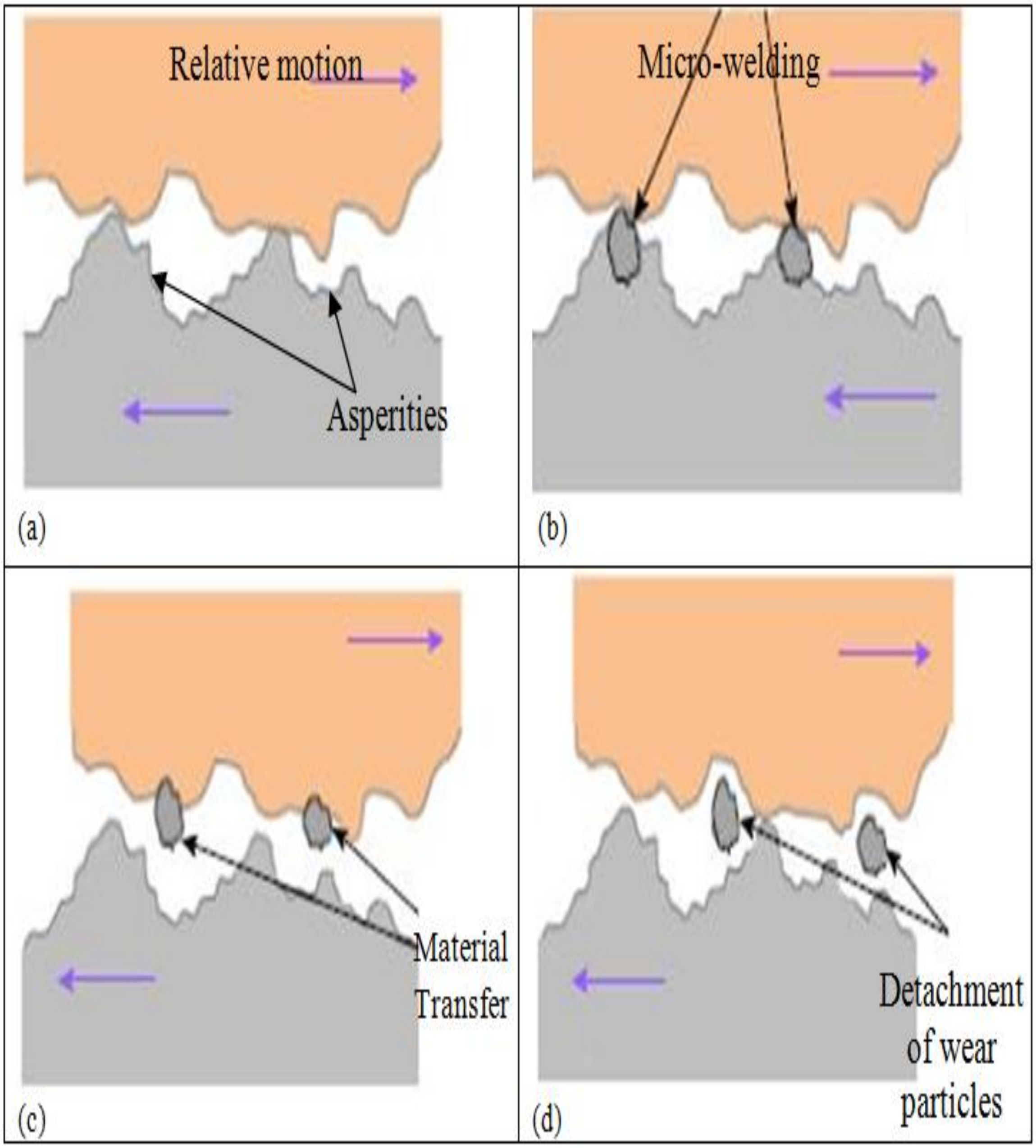

Fig 1.1: Mechanism of adhesive wear

1.2. 4 Wear adhesive

Wearing adhesive is when a hard rough surface slips against a soft surface, digs in it and binds several grooves. The ingredients, originally in the groove, usually emerge as loose pieces. It is known as wearing two bodies.
Wearing adhesive also happens when hard adhesive particles are introduced between two sliding surfaces and these particles either eliminate either or both materials. This mechanism is that a adhesive particle adheres to one of the temporarily sliding surfaces, or else it is embedded in it and removes the groove in the other surface. This form of adhesive wear is known as wearing three bodies.

When the sliding surface is smooth, two body wear are not much. Similarly, the three-body wear does not normally occur when the particles present in the sliding surfaces are small, or they are soft compared to slipping the material.

1.2.5 Wear corrosive

Wear the corrosive as a result of chemical reaction on the wear surface. The most common form of war is due to a reaction between metal and oxygen; However, other chemicals can also contribute. The corrosion product, usually oxide, has shear strength, which is different from the wearer surface metals which they form. Oxides come out, resulting in the position to wear the surfaces to reduce the friction effect. Potentially harmful potting for these bearings is harmful. Corrosive wear occurs in situations in which the environment surrounding a sliding surface is corrosive and the chemical contact with the slipping surface. As such, this wear is also known as "chemical wear".
Corrosive wear differs in war, in rust, there is no slippery surfaces and the reaction on the surface constitutes slowing the process with the increase in the thickness of the layer and after some significant thickness it can avoid further rust is; But when sliding surfaces it becomes corrosive and continues even when in that situation, the sliding process continuously wears reactions from the surface and releases fresh corrosive attacks.

1.2.6 Wear Aerosive
Irrosive wear is caused by particles that impose on any component surface or edge and due to motion, remove the material from that surface. This type of wear is especially seen with high velocity components such as servo and proportional valve. Particulars often hit the surface, this can cause surface denting and last fatigue. This is the damage caused by the sharp particles on any object. For example, particles in water, erosion of rocks on which a river flows, and both the erosion, rope and stone pulley when the rope continually slides over the pulley.

1.2.7 Fret Wearing
The fret is due to wear the friction of the components at the contact points due to minute oscillation, so the minute that the oil is displaced from between the parts but is not allowed to flow back in. Localization of the result of wear accelerates oxidation and wear. In effect, this localized dress is seen as a depression, which occurs during the determination of the brine hardness, hence the term is 'false brittleness'. An example would be the fret of motor vehicle wheel bearing when a car is taken by train. The car is safe, but the vibrations of the train on the tracks cause minute oscillation, which results in the effect of the false brittle effect of the race. FRET is defined as a complex wear or surface damage event, which is comfortable with contact with slipping on two contact surfaces or in relation to each other, usually with the moving speed of small dimensions. Relative speed is generally known as "slip". In general, there are fret between two tight fitting surfaces which are subject to cyclic relative motions of very small dimensions.

1.2.8 Wear the test and measurement

Wear test is done to predict the test of wear and to check the wear mechanism. Wear is measured to determine the quantity of (or worn) removed (and actually after a part in the service for a period of time) after wearing wear. Wearable material can be expressed on the basis of the weight of the weight (mass), decrease in quantity, or the purpose of the test as a linear amplitude change, the type of wear, the geometry and size of the test specimens, Never provide a measurement facility based on availability. The general techniques of wearer measurement include the loss of weight (mass), using a precise balance to measure the profiling surfaces, or using a microscope to measure the wear of the wear so that the wear or loss of the linear is determined Can go. Dimensional change

1.2.9 Massive loss

Large scale damage measurement measurement by a precise balance is a convenient way to wear, especially when the worn surface is irregular and odd in shape. The measured sample is carefully cured, and weight is measured before and after the test of wear. T

2.METHODOLOGY

A flow chart has been represented in Fig. 2.1 showing sequence of investigation.

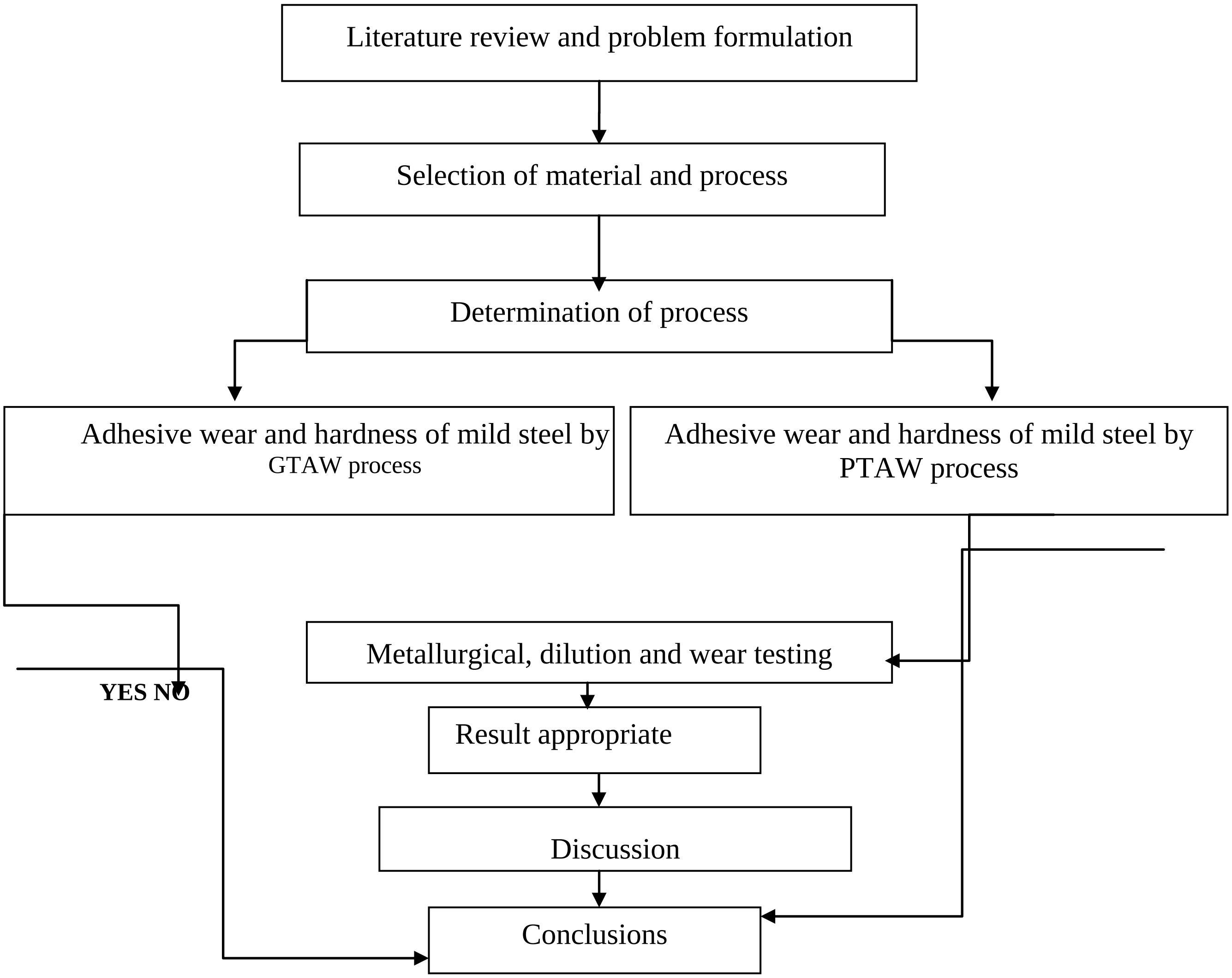

Fig. 2.1: Flow chart showing sequence of investigation

2.2Laboratory wear testing method

For testing of wear, a device is called as a tester, tribometer or tribottester. The prefix of "tribo" refers to wear, friction and lubrication. Many, perhaps more than several hundred, are used in laboratories around the world to arrange different wear and tear and process and are described in technical literature. Although the larger difference of one system than the other, the wearer examiner will always include two components to load and move forward against each other. The movement can be run by a motor or electro-magnetic device.

In the original nature of wear is intended to test some wear for fundamental research. Standard wear methods have been used for various reasons. Some standard wear test methods are listed in Table 1.3.

Table 2.1: Standard wear test methods

Designation	**Test description**
G-32	Vibratory cavitation erosion test
G-65	Dry sand/rubber wheel abrasion test
G-75	Slurry abrasivity
G-76	Erosion by solid particle impingement using gas jet
G-83	Crossed-cylinder wear test
G-98	Galling test
G-99	Pin-on-disk test
G-132	Pin abrasion test methods

2.3 A Pin-on-disc wear tester

In the pin-on-disc ware tester, a pin is loaded against a flat rotating disk sample, as if a circular wear path is described by the machine. The machine can be used to evaluate the wear and abrasion properties of the material in pure sliding conditions. Either a disk or pin can work as a sample, while the second counter forms the face. Pin with different geometric can be used.

2.4 An Adhesive Wear Tester

An adhesive wear tester, in which a wheel or a ball is operated by motor, rotates and slips against a certain sample in the presence of adhesive particles. The sample is in the form of plate or block. Contact pressure is controlled by dead weight through a loading lever. The adhesive particle, such as silica, gives a state of wearing three-body wear through a nozzle, joining a hopper above. After a set time of walking, the sample is removed, and the wear of the loss is measured. The parameters to control include contact load, sliding speed, type of adhesive particles and its flow rates.

2.5 A rolling sliding wear tester

The rolling sliding veer tester is the most popular tribometer for friction behavior of the material along with screening of wear under a combination of rolling, sliding or a combination of both. Two disks (wheels) are fixed for two parallel shafts and are pressed against each other under a constant contact load. Operated by motor through a train of gear, samples are roaming with shaft. Rotation speed can be controlled so that when the linear speed of two wheels v1 and v2 are equal at the point of contact, a pure rolling contact is obtained.

2.6 HARDFACING

Hard facing is a special depiction of special alloy material on the part of metal, through various welding processes, to achieve various desirable properties and dimensions. Generally, essential properties have more friction, effect, adhesion (metal to metal), heat, corrosion or any combination of these factors. This process is more economical than improving the desired properties of the entire component, because hard facing involves application of a coating for low cost base material. To increase service life, Hard facing is a low cost method for depositing resistant surfaces on metal components. Although primarily used to restore worn parts in the usable position, hard facing is also applied to new components before being placed in service. In addition to expanding the life of new and disconnected components, Hard facing also provides advantages like a lower replacement part, reducing downtime increases operating efficiency, less expensive base metal can be used, and The overall cost decreases.

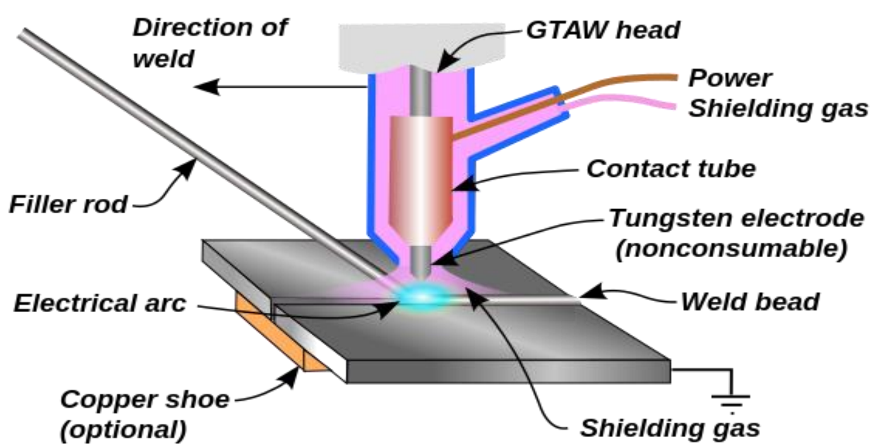

Fig. 2.2: Schematic view of weld hard facing

This is done by welding. Thus, this is part of a well-established practice with which people are acquainted. There are few new skills to learn and in most cases, existing equipment can be employed.

A layer or layer of metal can be deposited. This means that the hard facing provides security in depth. It can be applied to the thickness required for long lasting safety.

Metals of specific properties are deposited. There are several types of deposit types available, each of which is specially designed to wear and face certain forms of service conditions.

Hard facing only applies to specific areas of metal parts which are exposed to wear. There is often no need to protect the entire surface of a component from wearing. Hard facing can be selected and tailored to the precise requirements of a piece of equipment in different thickness, proving the most cost-effective way to wear.

@IJAERD-2019, All rights Reserved

2.6.1 Benefits of Hard facing

Hard facing extends the life of wearable components and equipment: build-up or hard facing can increase the life of one component by 250% compared to a new or non-rigid component.

Hard facing reduces downtime to increase the operating efficiency of the devices: hard fed components run for long periods, low shutdowns or pauses, and therefore increase the operating efficiency of the device.

Hard face parts can be made from cheap base materials: a part that is used hard surf before use can often be made from cheap base metal, which is not designed to make hard surf before use. goes.

• Hard facing reduces total costs: the cost of the worn components is usually 50-75% of the cost of a new component.

Less replacement of parts is required when parts are required when parts are hardened, hard facing reduces downtime because the parts stay longer and require fewer shutdowns to replace them..

2.6.2 Steps to be considered for Hard facing

Following steps should be considered while doing hard facing:

1. **Identify the base material**
2. **Select the product**
3. **Select the process**
4. **Select the hard facing alloy**
5. **Compatibility of the hard facing with the base material**
6. **Dilution rate and the overall cost**

2.6.3 Process used for Hard facing

In practice, there are many processes are available for hard facing like arc welding, gas metal arc welding (GMAW), submerged arc welding (SAW), shielded metal arc welding (SMAW), plasma arc welding (PAW), gas tungsten arc welding (GTAW) and flux cored arc welding (FCAW). In the present study GTAW process is used.

3. EXPERIMENTATION

3.1Preparation of base material

Three Mild steel (200×100×30) mm^3 plates have been selected on the basis of literature survey and the experience from the trial runs for present work. The mild steel specimen were taken as the base metal or substrate material upon which the hard facing material has to be deposited by GTAW welding

Before depositing the hard facing layers the specimen were thoroughly prepared cleaned mechanically and chemically in order to avoid experimental errors (Emery paper, acetone, grinding etc).

3.2Conducting actual runs

As per the data collected by the trial runs the actual experiments were conducted by laying down the beads of hard facing filler rod with present value of welding parameters.

Table 3.1: Parameter used in actual runs

Rod Diameter (mm)	4.00
Current (A)	100
Voltage (V)	20-22
Welding speed (mm/min)	110
Polarity	DCEN

.

Table 3.2: Nomenclature of samples as per number of layers

Samples	**Type of layer**
A	Single layer
B	Double layer
B.M.	No layer

@IJAERD-2019, All rights Reserved

(a) Single layer **(b) Double layer**

Fig 3.1: Different hardfaced plates

3.3 TESTING

After preparation of the specimens as discussed before, the following tests were performed:-

1. Metallurgical testing
2. Microhardness testing
3. Macrostructural and Dilution testing
4. Microstructural studies
5. Wear testing
6. Spectral analysis

3.4 METALLURGICAL STUDIES

3.4.1 Microhardness studies

Hardness is the ability of the metal to resist penetration, wear or the absorption energy under impact load. Hardness measurement provides information about the metallurgical changes caused by weld hardfacing in the various regions. The microhardness tests were carried out using Vickers's hardness tester with 2 kg capacity in order to analyze the above mentioned properties of the weld hardfacing deposits. Microhardness testing was conducted along and across the weld hardfacing cross-sections. Hardness of substrate (base metal), heat affected zone (HAZ), and hardfaced area with different layer were summarized. Hardness test was done at welding Metallurgy Laboratory of Mechanical Engineering department, SLIET, Longowal (punjab)

Fig. 3.2: Vickers hardness tester

The specimen representing different hardfacing layers as 1, 2, and base metal which denoted by hardfacing deposits A, B, and B.M. respectively were subjected to standard metallographic procedure for facilitating microhardness studies of these specimens. The standard metallographic procedure included grinding of specimens using different emery papers with grit size varying from 100, 200, 400, 600, 1000, 1200 and 1500. This was helpful in removing coarse and fine oxide layer as well as scratches on the surface that were to be metallographically analyzed. For the assessment of microhardness, the measurements were taken uninterruptedly at a distance of 1mm starting from the top of the weld bead. A load of 500g and a dwell time of 20 seconds were used for testing .

3.5 WEAR TEST

The wear test for all the samples was done on Pin on Disk apparatus. For calculating the wear rate, the samples were weighed before and after the wearing of a pin on the rotating disc and the difference between the initial and final weight were calculated. The weighing was done on a weighing machine with a least count of 0.0001gm. The sample was mounted perpendicularly on a stationary vice such that its one of the face is forced to press against the revolving disc. The revolving disc must be harder than the pin samples which results to wear the surfaces of samples. A standard specimen of cylindrical shape having dimensions (Length-30mm, diameter-8mm) was extracted from hardfaced plates .

The test was performed on Wear and Friction Monitor TR-201 machine at welding metallurgy lab SLIET, Longowal. Parameters of pin on disc test have been selected as per manual guide of machine and literature survey. Parameters considered during the test have been shown in Table 3.13.

Table 3.3: Parameter selected for wear test

Applied load	30N
Speed	500 rpm
Disk diameter	100 mm
Track diameter	60 mm
Test time	10 minutes
Sliding velocity	1.57 m/s
Sliding distance	942 meters

Sliding velocity = $\pi dN/60$ ***(mm/s)***

Sliding distance = sliding velocity × Test time (m)

3.6 SPECTRAL ANALYSIS

In present study spectral analysis was done to investigate the change in chemical composition in terms of weight percentage. Spectral analysis has been done at Advance Casting lab, SLIET, Longowal. The change in percentage of elements due to hardfacing was evaluated to measure the effect of dilution upon wear resistance and hardness. Each hardfaced sample was examined to its top layer and comparing with the base metal, helps to conclude the change the behaviour in wear, microstructure, microhardness and dilution

4. CONCLUSION

Based on the achieved results of the study of the structural compositions of hard facing, the measurements of their hardness and adhesive wear resistance, the followings can be concluded:

The hardness and wear values confirm the correctness of the principal that the maximum properties are not achieved by hard faced materials until the second layer. For practical application it is necessary to execute the welding process with minimum melting of the base material and low heat input. All samples with low heat input exhibited high alloy content and high proportions of martensite and retained austenite results high hardness.

In set condition of wear, the hard facing made up to two layers seem more favorable. The tough martensite and retained austenite dispersedly reinforced by a carbidic phase provides good resistance to adhesive wear. In terms of chemical composition and manufacturing technology, these hard facing appear economical despite of replacing worn out parts by new one.

Maximum hardness of 635 HV0.5 is achieved in two layer hard facing while 555 HV0.5 in single layer hard facing. Single layer hard facing deposit shows epitaxial growth in the deposits. One and Two layer hard facing samples shows a microstructure composed of martensite and retained austenite, with a pattern of dendrites segregation which became more refined. These changes result to increase in hardness.

Minimum wear rate of 0.0612 gm/hr is observed in sample B followed by wear rate of 0.1380, and 0.5070 gm/hrin sample A and BM respectively. From these obtained result it is concluded that increase in number of layers results to decrease in wear rate due to increase in hardness.

Minimum dilution of 20.53% is noticed in two layers hard facing while maximum dilution of 23.22% with single layer hard facing is observed. The dilution percentage has not much variation in multi pass hard facing because the melting of layer 2 and layer 1 does not show significant effect to mixing of layer and layer 1 with base metal.

Single layer of hard facing shows 75% more variation in weight percent compare to hard face filler rod and 338% more variation comparing base material. As the number of layer increased, the change in weight percent of elements at the top of one and two layer hard facing varied similar to the single layer compare to hard face electrode and base metal. As per average result Sample B has been observed the highest weight percentage of C, Cr, and other alloying elements i.e. percentage of formation of carbides results in increase in hardness and improved wear.

Based on the obtained results, it can be concluded that maximum results are achieved in two layers hardfacing in terms of high hardness and increased wear rate, though there was not too much increase in hardness w.r.t. one layer hardfacing. Therefore only to achieve the desired maximum hardness, two layer hardfacing is allowed otherwise two layer hardfacing is better as per economical point.

REFERENCE

1. . Zahiri, R., Sundaramoorthy, R., Lysz, P. and Subramanian, C., 2014. Hardfacing using ferro-alloy powder mixtures by submerged arc welding. *Surface and Coatings Technology*, *260*, pp.220-229.
2. Sood, A. and Singh, Y., 2015. Effect of GTAW Process on Wear Properties and Microhardness Test on the behaviour of Mild Steel and HB-600HT Filler Rod,*JMSME, 2(14)*, pp.9-13.
3. Kamboj, V., Bhushan, M.B. and Kumar, M.K., Optiomization of process parameters and Study of wear during hard facing of mild steel using taguchi method.*IJESRT, 4(3)* pp.652-661.
4. Brezinová, J., Draganovská, D., Guzanová, A., Balog, P. and Viňáš, J., 2016. Influence of the Hardfacing Welds Structure on Their Wear Resistance. *Metals*, *6(2)*, p.36.
5. Buchely, M.F., Gutierrez, J.C., Leon, L.M. and Toro, A., 2005. The effect of microstructure on adhesive wear of hardfacing alloys. *Wear*, *259*(1), pp.52-61.
6. Gualco, A., Svoboda, H.G., Surian, E.S. and de Vedia, L.A., 2010. Effect of welding procedure on wear behaviour of a modified martensitic tool steel hardfacing deposit. *Materials & Design*, *31*(9), pp.4165-4173.
7. Arsić, D., Arsić, D., Lazić, V., Lazić, V., Mitrović, S., Mitrović, S., Džunić, D., Džunić, D., Aleksandrović, S., Aleksandrović, S. and Djordjević, M., 2016. Tribological behavior of four types of filler metals for hard facing under dry conditions. *Industrial Lubrication and Tribology*, *68*(6), pp.729-736.
8. Lazić, V., Arsić, D., Nikolić, R., Aleksandrović, S., Djordjević, M., Hadzima, B. and Vičan, J., 2015. Influence of tempering on the deformation level of the multi-layer hard faced samples. *Procedia Engineering*, *111*, pp.49-56.
9. Sultana, M.N., Hasan, M.F. and Islam, M.,2016. Analysis of Mechanical Properties of mild steel Applying Various Heat treatment. *Journal of Material Sciences & Engineering*, p.1-4.
10. Elektrodami, a.m., 2012. Theoretical and experimental estimation of the working life of machine parts hard faced with austenite-manganese electrodes. *Materiali in tehnologije*, *46*(5), pp.547-554.

@IJAERD-2019, All rights Reserved