Investigation on microstructure of Al6061 Coating on Mild Steelplate By Friction surfacing

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Abstract- *Friction surfacing is one of the advanced techniques in the group of stir processing. Friction surfacing offers a means of producing coating between dissimilar materials through the solid state process. This process mainly used in the field of repair and reclamation of rough and damaged components. The applications of friction based technologies are increasing in various sectors such as Aerospace, Automobile, Electrical and many other industrial sectors. Friction surfacing is the technique for deposition of desired materials on the substrate by means of high friction. The friction between the base metal and consumable rod generates heat. Heat generation in consumable rod implies to melt over the surface of the substrate. No external heat source is required and heat is developed by friction.*

In this present investigation consumable of Al6061 ofdiameter20mmwereinvestigated for 5mm thick mild steel plate. Friction surfacing process is done making use of vertical milling machine. The rotational speed and of consumable rod can be varied for obtaining the good bonding strength of base metal and coating material. Surface roughness and microstructural transformation during the friction surfacing process is investigated by Atomic Force Microscopy and Metallurgical Microscope. The hardness of coated surface is investigated using Rockwell hardness test. The optimum hardness value has been obtained is 76.3 HRB at the speed of 280 RPM. Al6061,

Keywords- Friction surfacing, AL6061,MSplate,Surface Roughness

I. INTRODUCTION

Friction surfacing is a solid state technology, for coating the materials on the base metals by means of high friction. The high friction between the base metal or substrate and consumable rod generates the heat. Due to heat generation the consumable rod gets melted on the base metal and it can be coated over the base metal surface.

Friction surfacing is a one of the coating process by means of friction in surface of the materials. Surface science and engineering truces with the exterior of the hardest material and it is sub restraint of materials science. The solid material includes a granular or lumpy mixture of materials protected through an exterior surface and it is called outward phasing.

The applications of friction based technologies are increasing in various industrial sectors such as defense, aerospace, electrical, automobile and many other industrial sectors. Friction surfacing is a novel process in solid phase welding technique by means of which similar and dissimilar metals can be deposited one over the other effectively. In this process, the consumable is in the form of solid bar and is rotated with fixed speed and advancing the same under axial load onto the substrate, produces the frictional heat at the interface between faying surfaces. The moving parts are first subjected to dry friction during initial contact, after the rubbing action for a few cycles; there is a macroscopic local seizure and subsequent rupture by plastic deformation. This leads to third body layer of finite thickness over the surface of the substrate. Then the substrate is moved onto the substrate material with a fixed feed rate to achieve the desired thickness of the deposit. The presence of high contact stress, removes oxide films over the substrate surface. Surfaced deposits are achieved through hot rotary forging action between mechtrode and substrate at forging temperature and are homogeneous and of god strength. The torque- time characteristics are important for the quantum of heat generated.

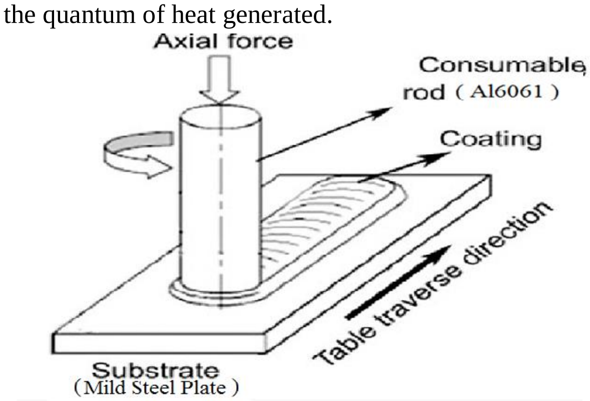


Figure 1.1 Schematic diagram for Friction Surfacing

II. EXPERIMENTAL SET UP AND FABRICATION

2.1Vertical Milling Machine

Vertical milling machine, Radial drilling machine and Lathe machine with special attachments were used for friction surfacing. Presently the friction surfacing and stir machine is available in R&D labs which concentrating on joining of dissimilar metals by friction surfacing. But aluminum is deposited by making recess in the substrate in the air using Vertical milling machine.

In our experimentation a relative motion is produced between the substrate and mechatrode by rotating the substrate material and mechatrode material as stationary. In the experiment, the substrate is rotated with preferable speed and the mechatrode is made to contact with that rotating substrate.

Here the substrate and mechatrode are in perpendicular planes.

The friction surfacing has a very good potential for surfacing techniques in the areas of (i) joining similar and dissimilar metals such as aluminum over aluminum, (ii) stainless steel, high speed steel, inconel and satellite on mild steel. But it is observed that mild steel is deposited with better bonding by friction surfacing than the stainless steel, it may be due to lower hardness and plasticizing temperature. Brass and aluminum consumables failed to form a heated layer in contact with the mild steel, high thermal conductivity of either metal being the probable cause of failure to perform friction surfacing. Tool steel can also be deposited over the low carbon steel, but obtaining better microstructure and properties post-surfacing treatment is required.

The friction surfacing process was performed using mild steel with a thickness of 5mm as the substrate and a consumable rod made of Al6061 with the composition. The diameter and length of the Al6061 aluminum alloy consumable rods used in this investigation are 20mm and 100mm, respectively. In the friction surfacing experiments, 75-125mm/min axial feeding rate, the rotational speed of 200-500rev/min, and the traverse speed of 50-75mm/min wereused**.**

Figure 2.1 Vertical Milling Machine

The vertical milling machine is used for coating the Al6061 on Mild steel plate as shown in figure 2.1. In milling machine cutting tool is changed to A6061 for coating purpose.

Figure 2.2 Friction surfaced samples

Figure 2.3 Prepared samples for Hardness test, Microstructural analysis and AFM

Table 2.1 Friction surfacing process designation

Sample no	Speed (rpm)	Axial feed (mm/min)	Traverse speed (mm/min)
1	200	75	50
2	250	75	50
3	280	75	50
4	300	75	50

2.2 TESTING OF SAMPLES

The samples were coated as per the experimental plan to prepare specimens for various testing and investigating the properties of these fabricated samples.

2.2.1ROCKWELL HARDNESS TEST

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation.

The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter. First, a preliminary test force(commonly referred to as preload or minor load) is applied to a sample using a diamond or ball indenter. This preload breaks through the surfaceto reduce the effects of surface finish.

After the preload, an additional load, call the major load, is added to reach the total required test load. This force is held for a predetermined amount of time (dwell time) to allow for elastic recovery. This major load is then released, returning to the preliminary load. After holding the preliminary test force for a specified dwell time, the final depth of indentation is measured. The Rockwell hardness value is derived from the difference in the baseline and final depth measurements. This distance is converted to a hardness number. The preliminary test force is removed and the indenter is removed from the test specimen.

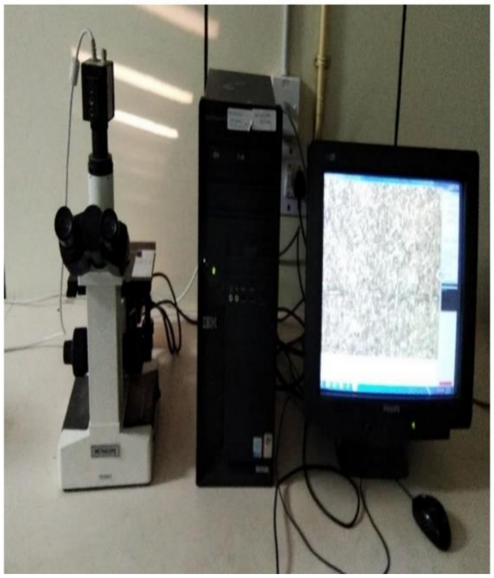
A variety of indenters may be used: conical diamond with a round tip for harder metals to ball indenters ranges with a diameter ranging from 1/16” to ½” for softer materials.

When selecting a Rockwell scale, a general guide is to select the scale that specifies the largest load and the largest indenter possible without exceeding defined operation conditions and accounting for conditions that may influence the test result.

Figure 2.4 Rockwell Hardness testing machine

2.2.2 OPTICAL MICROSCOPE

The optical microscope, often referred to as the light microscope, is a type of microscope that commonly uses visible light and a system of lenses to magnify images of small objects. Optical microscopes are the oldest design of microscope and were possibly invented in their present compound form in the 17th century. Basic optical microscopes can be very simple, although many complex designs aim to improve resolution and sample contrast. Often used in the classroom and at home unlike the electron microscope which is used for closer viewing.



2.5Inverted microscope setup

2.2.3 ATOMIC FORCE MICROSCOPY

Atomic force microscopy (AFM) or scanning force microscopy (SFM) is a very-high-resolution type of scanning probe microscopy (SPM), with demonstrated resolution on the order of fractions of a nanometer, more than 1000 times better than the optical diffraction limit.

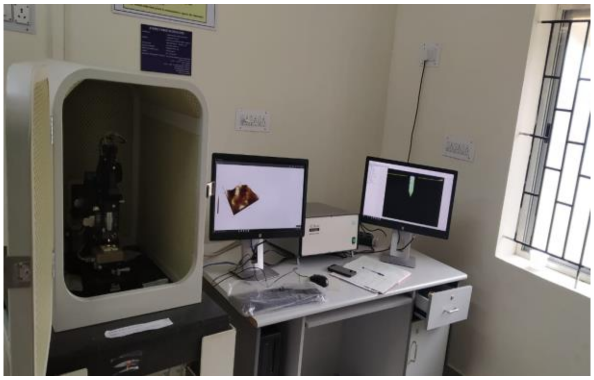


Figure 2.6 Atomic force microscope setup

III. RESULTS AND DISCUSSION

3.1 TESTING OF SPECIMEN

3.1.1 TEST RESULTS

The following tests are conducted with test specimen of coated samples.

- Rockwell Hardness Test
- Microstructural analysis
- Atomic force microscopy test

3.2 Rockwell Hardness Test

Rockwell Hardness Test at various locations and parameters was carried out to know the effect of Al6061 coated Mild steel as given in Table 5.2. Rockwell hardness measurement has been carried out on the embedded coated substrate.

Table 3.1Rockwell Hardness test specifications

1	Applied Load	100 Kgf
2	Scale	B scale reading
3	Indenter	Ball type indenter
4	Indenter diameter	1/16" inch ball

Table 3.2 Rockwell Hardness Test Values

S.No	Sample	Speed (RPM)	Hardness (HRB)
1	Sample 1	200	61.3
2	Sample 2	250	73.3
3	Sample 3	280	76.3
4	Sample 4	300	75.9

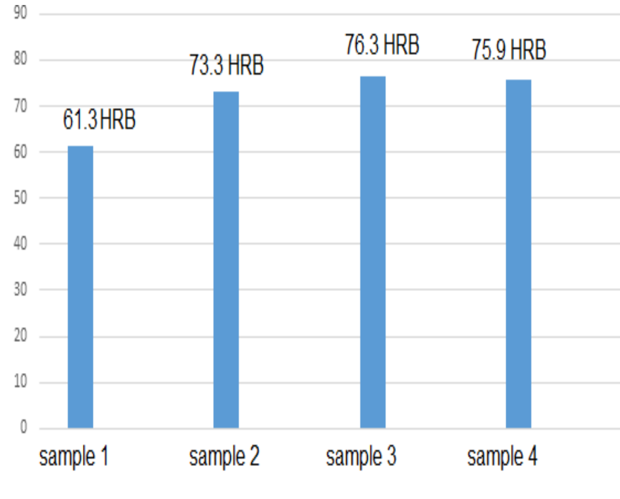
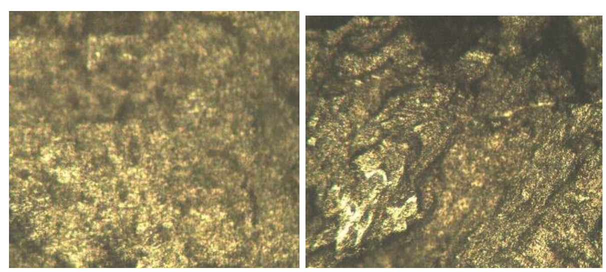


Figure 3.1 Comparison Chart

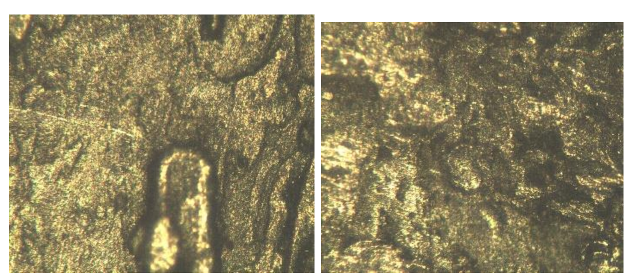
The comparison chart compare between the different speed and Rockwell Hardness test values. It results that maximum hardness value obtained at the speed of 280 rpm.

3.3 MICROSTRUCTURAL ANALYSIS

The microstructure of coated samples are taken by the optical microscope, the microstructure of different samples are shown in following figures.



Microstructure of sample 1
Microstructure of sample 2



Microstructure of sample 3
Microstructure of sample 4

Figure 3.2 Microstructure coated of samples

3.4ATOMIC FORCE MICROSCOPE TEST

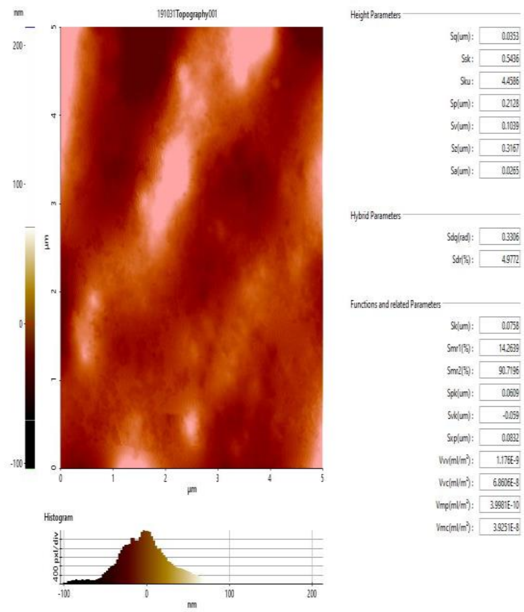


Figure 3.3 roughness graph of coated surface

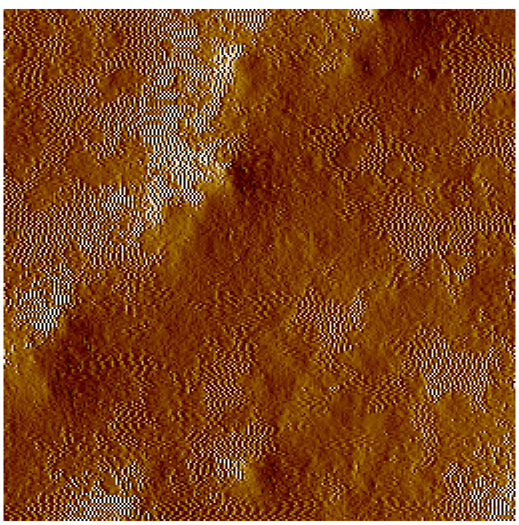


Figure 3.4 AFM Test sample

In following figures shoes the roughness and microstructure of coated samples in this sample the optimum peak value is obtained at 120 µm.

IV. CONCLUSION

The bond coated base substrate is the base of the coating. The Al6061 is coated on the Mild steel plate. The coating process is done by Friction surfacing. The coated specimen is investigated mechanically and analyzed characterization.

Friction surfacing using a conventional machine controlling the rod feed rate produced homogeneous deposited layers, showing consolidated joining with the absence of porosity or inter metallics along the retreating, center and advancing regions.

- Friction surfacing produced microstructural deposits of refined grains with 24.1% Lower hardness values than the consumable material as-received.
- Friction surfacing controlled by the rod feed rate induced a decrease in hardness value at the central substrate region of 15.87% in relation to the substrate material as-received.

The Al6061 on Mild steel is required closer control of process parameters to obtain uniform coating, good adhesion bonding and coating integrity between coating and substrate. The deposits obtained by friction surfacing were observed by metallography showed dense, clean and fine microstructure

The hardness of the coated specimen is higher than the uncoated Mild steel which is obtained by Rockwell Hardness Test. The optimum hardness value has been obtained is 76.3 HRB at the speed of 280 RPM.

The coated sample surface roughness can be investigated by Atomic Force microscopy and it shows the topography of the coated samples the roughness peak value are obtained in the range of 120 µm.

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