Deposition of AA5083 on Mild steel by Friction Surfacing: Hardness and Wear Characterization

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***Abstract*--Friction surfacing (FS) is a solid state coating technique with application of rehabilitation of worn out parts and act as corrosion barrier. It is suitable to process aluminium alloys as it does not require the fusion of neither coating nor substrate, relying on solid state diffusion bonding mechanism. The present study addresses the use of FS to deposit AA5083 on mild steel, with emphasis on hardness and wear characterization. Wear rate can be examined by Pin-On-Disk method. Hardness of the coating can be determined by vicker's hardness survey. An improved coating hardness and wear performance was observed while compared to previous results.**

***Keywords*--Friction surfacing, aluminium, mildsteel, hardness, wear rate.**

ABBREVIATION

FS	: Friction surfacing
AA 5083	: Aluminum 5083
HV	: Vicker's Hardness
MS	: Mild steel

INTRODUCTION

Friction surfacing has significant notice in the past decade as a solid state hard facing method to produce wear and corrosion resistant coatings. The ability to generate coatings without any melting makes this process different from other conventional coating processes. The fundamental principle of friction surfacing is related to that of friction welding. Severe plastic deformation due to collective action of frictional heating and pressure forms the foundation of the processes. A rotating rod (cylindrical), which is the coating material, is rubbed against a metallic substrate, with applied force such that the rubbing surface of the rod gets adequately heated up by friction and become softer due to severely plastic deformation. The softened plasticized material then starts to flow (during the movement of the substrate) and settled over the substrate. Here, only the rubbing surface of the mechtrode gets preferentially softened due to the variation in energy balance between the substrate and mechtrode. A schematic of friction surfacing is shown in Fig. 1. Friction surfacing can be considered for broad range of applications where wear and corrosion becomes a foremost concern. Previous studies on friction surfacing clearly shows the suitability of the process in concern wear resistant and corrosion resistant coatings. Another important area where FS process can be considered for repair and repossession of worn-out engineering parts such as dies and related tooling which might have been developed the surface cracks by thermal exhaustion. Fusion welding is frequently adopted to restructure these cracked surfaces.

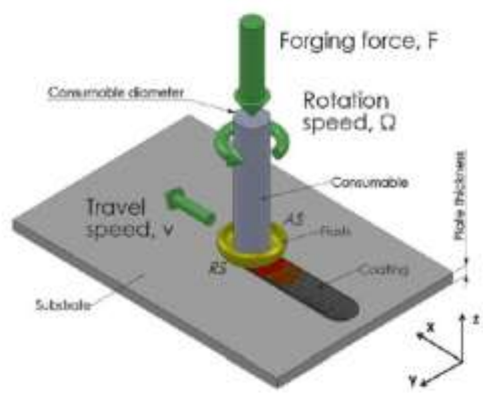

Fig.1. Schematic View of Friction Surfacing Process (Gandra et al 2012)

Unfortunately, fusion welding techniques are distinguish by high temperature rise, which results in the increase of high thermal stresses, and a quick solidification, which gives rise to the occurrence of separation phenomena and the occurrence of non-equilibrium phases. To contract with this issue, the parts are often subjected to pre-heating and post-weld heating actions. Being a solid condition process, friction surfacing is free from the above stated troubles. Hence, by using friction surfacing to fill up the cracked region, the heat treatment procedures can be eradicated. This will considerably decrease the processing time and more importantly consequences in better metallurgical properties of the tools.

MATERIAL SPECIFICATION

Table 1 Chemical Composition of AA 5083

Element	% Present
Si	0.4
Fe	0.4
Cu	0.1
Mn	0.4-1.0
Mg	4.0-4.9
Zn	0.25
Ti	0.15
Cr	0.05-0.25
Al	Balance

Table 2 Chemical Composition of Mild Steel

Element	% Present
C	0.14
Fe	98.81
Mn	0.60
P	0.04
S	0.05

EXPERIMENTAL WORK

A Mild steel plate of 150mm length, 100mm width, 6mm thickness was taken as the base substrate material for friction surfacing. Aliminium AA 5083 of 25mm diameter and 120mmlength is used as a mechtrode material. The friction surfacing process is carried out in vertical milling machine at RV Machine Tool, Coimbatore. The chemical composition of AA 5083 and Mild steel plate are given in Table 1 and 2. The micro hardness survey can be taken in Vicker's hardness machine and wear characterization is determined by Pin-On-disk method. The friction surfacing of aluminium over the mildsteel is shown in Fig. 2.

Fig.2. After coating of AA 5083 over Mild steel and the formation of layers along the plate

PARAMETER OPTIMIZATION

The process parameter for friction surfacing is selected by Trial and error method and refereed with previous literature surveys. The process parameter for the surfacing process are listed as follows.,

Table 3 Process Parameter of Friction surfacing of AA5083 over MS

Rotational speed, rpm	Traverse speed, mm/min	Plunge feed, mm
1700	80	7
1800	100	10
1900	120	13

HARDNESS COMPARISION

The result of Vicker's micro hardness survey taken across the coating substrate interface and uncoating surface is shown in Fig. 3. The coating reveals micro-hardness of about 800 HV, which is much superior than the hardness of the as-received material. The presence of carbides could also extend to the increase in coating hardness. Minor increase in hardness can be observed in the substrate region closer to the interface. This is due to the thermal digression and modification in microstructure that accompanied it.

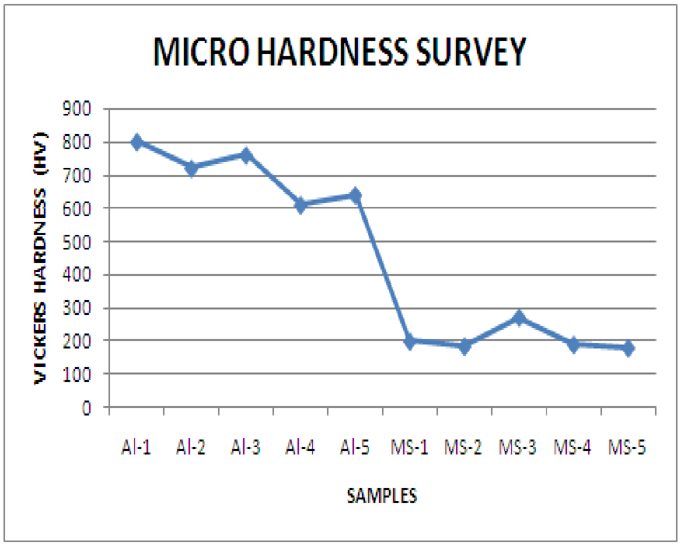

Fig.3. Hardness comparison of coated and non coated samples

The above figure reveals that hardness is much greater than uncoated samples due to continuous flow of grains in which thin layer of coating is formed.

WEAR RATE

Wear characterization of the coating was examined using Pin-on-Disk (ASTM: G99-05(2010)) wear testing method. Pins of 8 mm diameter and 70 mm length were extracted from the aluminium coating. Coating was subjected to stress relieving treatment to avoid any cracking during machining. 12 mm thick of disk and 50 mm diameter were machined out from mild steel bar stocks. Wear tests were conducted at 10 kg load, 1 m/s sliding velocity for a total distance of 1000 m. Process Parameter of Wear Test are listed in Table 3. To ensure the reproducibility of the results, tests were repeated twice.

Table 3 Process Parameter of Wear Test

Parameter	Value	Unit
Sliding Velocity	1	m/s
Sliding Distance	1000	m
Track Diameter	50	mm
Load	10	N
Experimental Duration	17	min
Disc Speed	318	rpm

Table 4 Material loss from the pins during wear testing

	Pin weight (g)			Volume loss (mm^3)
	Initial	Final	Loss	
Coating	6.9306	6.9280	0.0026	0.326
	6.9844	6.9267	0.0017	0.245

The Table 4 shows the wear characterization of aluminium coating of 2 pins. The sliding wear behavior of the coating was examined based on the material loss. For relative purpose, wear testing was also carried out for pins extracted from the aluminium coatings. The mass loss of the pins measured using a digital balance, after each test was converted to Volume loss and represented in Table 4. As projected, the material loss for the pins from coating is minor as compared to the pins from as-received material. The better wear resistance of the coating could be qualified to the improved micro-hardness.

CONCLUSION

Friction surfacing of AA5083 coatings is found possible on a moderately softer low carbon steel substrate. A lower rotational speed of the mechtrode and higher traverse speed of the substrate gave thinner coatings which reveal superior bond strength. The severe plastic deformation involved in friction surfacing process end up with grain improvement of the coating by dynamic recrystalization. The AA 5083 coatings show enhanced micro-hardness and wear resistance due to the refinement of primary carbides.

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