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Factors Affecting Friction Surface Coating on Aluminium Pipe

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***Abstract**: Aluminium is widely used for Aerospace, Automotive, Marine, Rail, Building, Packaging and Mechanical industry and engineering applications because of its ease in fabrication and the moderate strength it posses. Comprising a little over 8% of the earth's crust, aluminium is the most abundant metal on the planet. It is the third most common element after oxygen and silicon. In our lifestyles and built atmosphere, aluminium products are nowadays as abundant. Since its commercial production began little more than a century ago, aluminium has become the material of choice for a diverse range of application and utilities. The natural qualities of aluminium and its alloy are positive deciding factors for designers, manufacturers and industrial user who will be always on the beware for better- performing materials and modern processes. Deposition of zinc on aluminium by mechanical process is challenging to improve the surface characteristics of aluminium. The corrosion resistances of steel were improved due to deposition of zinc. Solid metal deposited on another solid by mechanical action. The parameters are speed, feed and forward time used in the process to develop the coating. The analysis of Hardness, surface Roughness, XRD, EDAX and SEM results shows zinc deposited on aluminium varies with varying process parameters. The lower crystalline size of the zinc deposited on steel at higher speed, lower feed and lower forward time. The metal is softened at higher speed due to high friction generated. Zinc deposited on aluminium increased due to increased friction in the process. The coating thickness of the internal surface of the pipe varies with the speed of the pipe at the forward time and feed.The study reveals it is a technique to improve the properties at the interface between aluminium and zinc.*

***Keywords:** Coating, Friction surfacing ,metallurigical bonding, properties of inter surface and Process parameters. XRD analysis;*

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I. INTRODUCTION

Applying a substrate to an object is known as coating. Scratch resistance, corrosion resistance, adhesion, wear resistance, wet ability appearance can be improved by applying coating. In finished part coating forms an essential part in printing and semiconductor device fabrication. Deposition of mild steel (-25 µm diameter) on low carbon steel, particle interaction were analyzed. During deposition of powder to estimate the temperature a model simplified energy conservation was developed during powder deposition[1].At low temperature and types of dependence and dispersion characteristics of metallic compounds, for inter metallic compounds, post annealing of cold sprayed are investigated[2].

Formation of coating was affected by post treatment spraying parameters and powder characteristics in cold spraying are the optimal technique. Criterions for corrosion resistance are denseness and impermeability. Through corrosion test denseness is evaluated. On substrate side and particle bonding takes place due to the deformation process as surface temperatures plays key role. Through four – point bending test mechanical propeller of low pressure cold sprayed mild steel coatings and deposition of mild steel are focused by the effect of surface condition[3].Newly formed substrate surface and through several impingements of particle surface are to be obtained inactive native. Oxide films have adverse effect for coefficient particle deposition[4].To reaction magnesium components US army research laboratory (ARL) developed cold spray process which is improved on other methods for rotorcraft use in qualification process[5].High resolution electron microscopes observed micro structural development and behavior of deposition from single particle to thick coating layer. By the impact of sprayed particle along the boundary of inter facial single titanium which was sprayed on to the substrate was grain refined and deformed[6].High –velocity oxy fuel frame (HVOF), detonation gun (D- gun) control, injection, powder morphologies, residual stresses, coating microstructures, reproducibility of coatings, properties are needed for the research to study thermal spraying as per our current knowledge[7].Industrial coating technology was emerged and cold spray technology. They are originated from the institute of the theoretical and applied mechanics Siberian branch of Russian academy of Russian science. To induce several plastic deformation and creating deposit, cold sprayed particles with high velocity are impacted were investigated in this study in vitro degradation[8].

Friction stirs process chances for alloy degradation resistance which is attributed to secondary phase. Particles dissolution which was simulated by electrochemical experiments[9].In micro – areas of materials high gradient of thermal field was initiated which is subjected to FSP and FSW processes in analysis of mass transport. In structural systems and analysis focuses on Fe – Ni and Fe Cu diffusion system practically[10].Using pin-on-disk, wear –testing machine dry sliding wear behavior of die cast mild alloy which was reinforced with copper coated short fiber was investigated. For wear resisting coatings and deposition corrosion friction surfacing is a candidate process[11].

Dependent on the rotation than transverse speed thermocouple measurements, extract of material mixing, tool torque and macro structural observation indicate temperature under tool which is strongly dependent.Separate module of microstructure evaluation calculation and hardness distribution results was developed by providing a numerical three dimensional heat flow (3-D) in investigation. By using high speed CNC lathe machine deposition of 200^0c on mild steel was concentrated[12]. The present study is focused on statement of zinc on mild steel by utilizing High speed CNC Lathe machine.

II. EXPERIMENTAL WORK

2.1. MATERIAL SELECTION

Comparing to pipe material, total material has melting point and low hardness. Upon zinc; mild steel is deposit. The composition of tool and pipe materials is as follows shown in Table 1.

Table 1: Composition of Tool material and pipe material

	Composition of Parent Metals	
S.No	Tool material (Zinc)	Pipe material (Mild Steel)
1	99.9%Zn, 0.06P, 0.04S	99.9%Al, 0.05P,0.05S

2.2. Tool Design

In the mild steel pipe, zinc is deposited as coat inside the pipe. For fitting as per dimensions and it is made up with zinc billet and it is made to tool shape. A device which contains of rectangular cross section hole which is made in rectangular shape was designed for holding tools as shown in Fig.1.

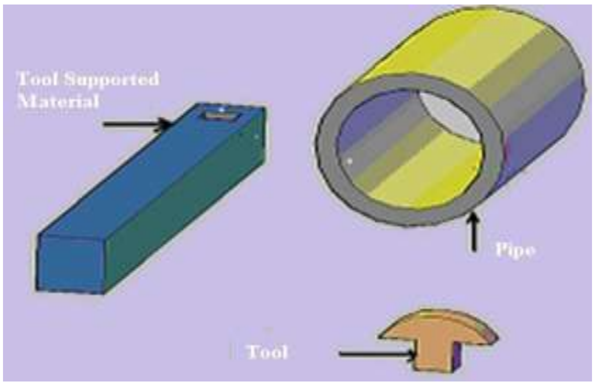


Fig. 1: Auto CAD model of tool and pipe

2.3.Experimental setup

In CNC lathe machine a tool with pipe material is fixed which is designed as per dimensions and the pipe is fixed in rotary members and tool is fixed in stationary member. By friction technique, CNC lathe machine is selected for coating. The tool is fixed in stationary members and the pipe is fixed in rotating members and the tool is getting in to the pipe then it meshes.

For setting external curvature with internal curvatures of the curvatures of pipe the center of pipe the centre of pipe is adjusted with tool post. With the given speed of pipe, pipe always gets in contact with tool. According to the selected parameters the tool will slowly feed in forward direction and then after it will move in reverse direction. Tool is in stationary and pipe is in rotary when the friction generated between pipe and tool it is due to metal to metal contact and internal surface is formed in thin layer and the from pipe tool is removed and then in pipe material a thin inter metallic and its parameter are shown in Table 2.

Table 2: Hardness and Surface roughness varying with Processing Parameters

	Parameters			**Hardness**		**Surface Roughness**	
Sample. No.	**X_1**	**X_2**	**X_3**	**AL_c**	**AL_{wc}**	**AL_c**	**AL_{wc}**
1	600	0.045	5	150.98	150.98	1.76	0.638
2	600	0.045	8	164.71	160.72	1.41	0.407
3	800	0.045	5	160.15	167.2	2.50	0.39
4	800	0.045	8	153.53	144.92	2.42	2.10
5	600	0.05	5	134.43	130.27	1.89	0.397
6	600	0.05	8	160.82	158.04	1.60	0.396
7	800	0.05	5	153.98	144.96	2.44	0.859
8	800	0.05	8	140.15	142.07	1.14	0.398

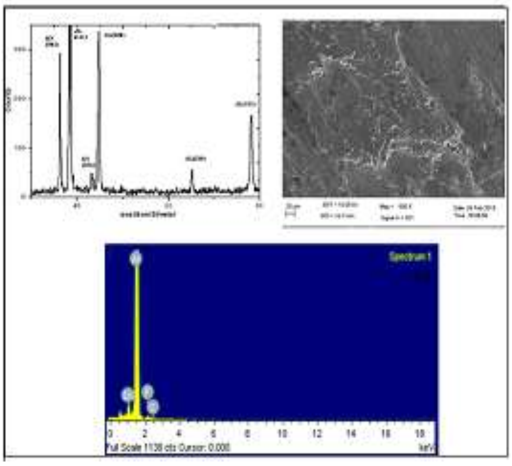
Where X_1 = Speed (N) in rpm X_2 = Feed in mm/rev
X_3 = Forward time in min AL_c = Aluminium coated with zinc
AL_{wc}= Aluminium without coating

Friction is generated between tool and pipe when the tool touches the pipe surface in forward direction. Wear of tool and softening of tool surface takes place due to this friction and in internal surface of pipe deposition takes place. Improving the surface finish of pipe in less time When the tool moves in reverse direction.

III. RESULTS AND DISCUSSIONS

3.1XRD SEM AND EDS PATTERN OF ZINC DEPOSITED ON ALUMINIUM

In the XRD pattern of the Zinc deposited on Al, the peaks are observed at 36.290, 38.471, 43.221, 44.720, 65.095 and 78.227 the (h k l) values of the peaks are (0 0 2), (1 1 1), (1 0 1), (2 0 0), (2 2 0) and (3 1 1) respectively. These results are coincided with JCPDS card number 87-0713 for Zinc at 36.290 and it shows hexagonal structure, the peaks which are coinciding with JCPDS card number of 65-2869 for Al at 38.471 and it shows cubic structure, the peaks which are coinciding with JCPDS card number of 87-0713 for Zinc at 43.221 and it shows hexagonal structure, the remaining peaks are coinciding with JCPDS card number of 65-2869 for Al at 44.720, 65.095 and 78.227 it shows cubic structure is shown in figure 2 . The average crystalline size is measured using Debye-Scherer’s formula.



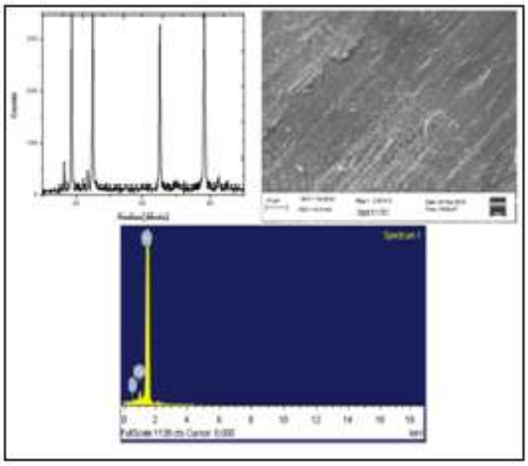


Figure: 2 .Zinc deposited on Aluminium at the condition of 800-0.045-5 shows on (a) XRD Patter(b) SEM (c) EDAX Analysis

Figure: 3.Zinc deposited on Aluminium at the condition of 600-0.045-5 shows on(a) XRD Patter(b) SEM (c) EDAX Analysis

According to the Debye-Scherer's equation:

$$D = \frac{0.9\lambda}{\beta cos\theta} nm \quad (1)$$

Where D – Average size of the particle (nm)
λ-Wavelength of the radiation (A°) θ –Diffraction angle (degree)
B – Full width half maximum (FWHM) of the peak (radians)

From the above equation, the obtained average crystalline size is 18.74nm.

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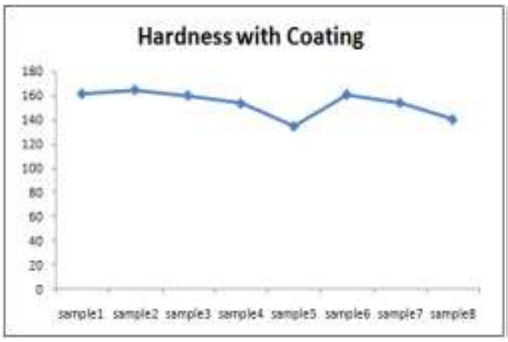
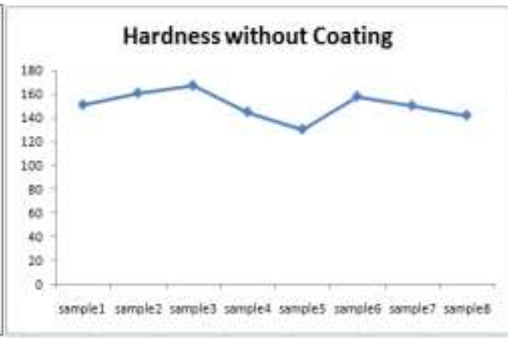
From the above formula obtained average crystalline size is 20.11 nm.





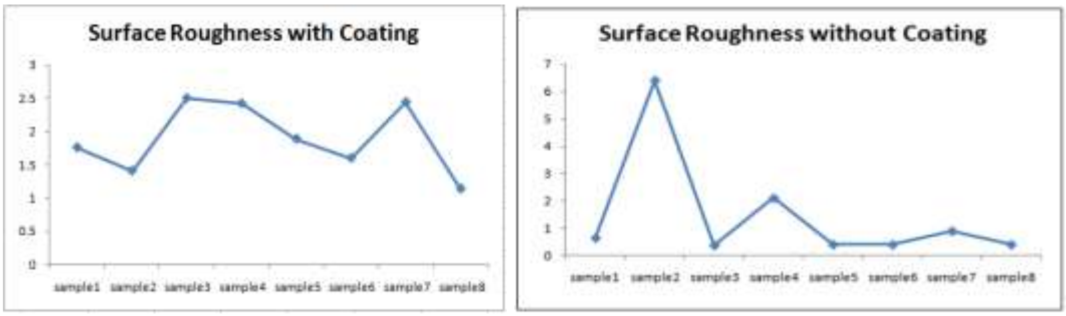


Fig 3 (a) (b) (c) & (d) images of Hardness & Surface Roughness (with coating & without coating) of Zinc deposited on Aluminium by friction surfacing

3.2. HARDNESS

The parameters are plays a greater role to improve the hardness of coating, which is deposited inside surface of the Alumnium pipe. The parameters used in the experimentation are pipe speed, feed rate for tool and forward time for tool. The condition of low speed, high feed and low forward time results higher hardness. The other properties are moderate at the same condition as mentioned above. As per the regression analysis the individual parameter of feed contributes maximum to improve the hardness whereas speed and forward time contribution is minimum. All the interaction parameters of speed, feed and forward time contributes to improve the hardness are shown in figure 3 (a) & (b) .

3.3.SURFACE ROUGHNESS

The surface roughness is varied with respect to parameters of the process. Here minimum speed, feed and higher forward time are contributed good surface finish. At this condition, the hardness is low and the better corrosion resistance whereas coating thickness is moderate. As per regression analysis, the individual parameters of speed, feed and forward time contributes minimum to the surface roughness. The interaction parameters of speed and forward time contributes maximum to improve the surface roughness where as other interaction parameters are minimum are shown in figure 3 (c) & (d).

3.4. CROSS-SECTIONAL MICROSCOPY AND COATING COATING THICKNESS :

Deposition of -thickness is fairly uniform, and measurement over 1 mm length gave thickness in the range of 90 to 106 um. Interface is macroscopically smooth, without any profiles created during surface milling. This is more clearly visible in the Figure 4. It presents the interface between substrate and the material-deposited. The interface is relatively smooth and small. The composition profile across the interface (Figure 4(a)) shows minimum (almost zero) level of mixing of species on either side of the interface. This statement is without considering the material transfer in the form of particles which are visible as white particles (Al) particles of nanometer scale (interface) embedded in zinc matrix. The average spacing between the particles is also very small, indicating that they would contribute for particle strengthening . Strong Al particles are expected to strengthen soft Zn matrix.

From the figure 4 it shows the deposition of zinc metal inside the Aluminium pipe by mechanical action. The microstructure shows interface of zinc deposited inside the Aluminium pipe.

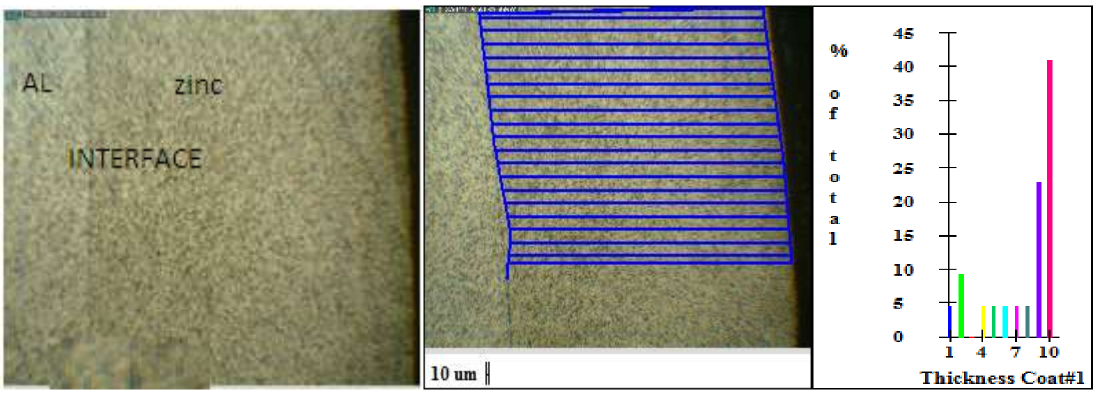


Fig 4: (a) (b) & (c) Microstructure Coating Thickness & Graph of Zinc deposited on Aluminium

IV. CONCLUSIONS

XRD pattern of Zinc deposited on Aluminium by friction surfacing shows, the average crystalline size is 18.74 nm & 20.11nm. Due to proper deposition of zinc, it shows fine surface finish by scanning Electron Microscopy (SEM). Deposited Zinc consisted of small Al particles dispersed in it. The interface between substrate material and deposited material is smooth and relatively sharp. A mechanism for the formation of a composite layer is presented using shearing, mixing, and deposition of plastic material during surfacing..For friction surfacing three different set of parameters were applied to get the minimum thickness and surface roughness.

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