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Effect of Rotational Speed on Coating Thickness during Zinc Deposition on Copper by Friction Surfacing

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***Abstract:* - Copper has excellent thermal conductivity and is mainly applied in electrical and machinery applications, excellent workability and reproducibility, apart from these it is cheap and abundantly available metal other than good conducting metals like silver. But has poor mechanical properties such as hardness and wear resistance. Its main disadvantage is its poor resistance in aggressive environment which can be significantly enforced by the coating of ZnO. It is one of the most effective ways to protect copper components because of its ability to form Cu-Zn components which is more resistant to oxidation. Zn is very reactive with oxygen and form ZnO which is impermeable for most of the atmosphere elements, so their presences on the surface of the coating passivate the substrate from further oxidation. For this study, the effect of deposition time, coating thickness and microstructure of Zinc coatings on Copper substrates by friction surfacing process using a Vertical Milling Machine apparatus, was investigated. The effects of longitudinal feed on the geometry and mechanical properties of coatings are studied. Metallurgical studies were made using optical microscopy.**

Keywords: Rotational speed, Feed, Microstructure analysis, vertical milling machine.

I. INTRODUCTION

Copper is one of the most important metals. It has excellent thermal conductivity and is mainly applied in electrical and machinery, applications. Malleability and ductility which make them suitable for a great variety of metallurgical applications such as oxygen nozzles in copper making converters and slag hole in blast furnaces, along with many others continuous casting copper moulds [1]. Zinc have been chosen as coated material because, freshly exposed galvanized copper reacts with the surrounding atmosphere to form a series of zinc corrosion products. In air, newly exposed zinc combines with oxygen to form a very thin zinc oxide layer [2]. Friction surfacing is a solid state deposition process for producing wear and corrosion resistant coatings on metallic surfaces, which involves a rotating rod pushed against a horizontally moving plate. The rotating rod is the coating material and the plate is the substrate. The width of the coating depends on the diameter of the consumable rod and is normally in the range of 0.9 times the rod diameter [3]. In this work, the effect of longitudinal feed on coating characteristics have been investigated for friction surfacing (using vertical milling machine) of zinc on copper. The results showed that the significance of longitudinal feed in producing coating with good bonding strength [4].Surface roughness tool is used to roughen the surface of the copper substrate for fine deposits. Used tool is as shown in the figure 1.

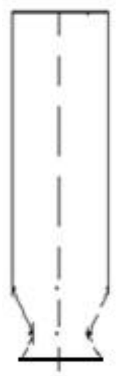

Fig 1: surface roughness tool

After deposition of zinc on copper, at various locations on that coated region we have studied the microstructure byusing optical microscope with aver cap software.

II. SAMPLE PREPARATION

The copper was selected as substrate, substrates were collected from hot rolled copper strip by cutting it into averagely 300mm*170mm*5mm size piece. For operating conditions, the substrate was cut into 3 plates with dimensions as 300mm*10mm*5mm in size. Using scriber and ruler we marked 170mm*100mm space over the substrate & by making use of surface roughness tool, roughed the surface of the substrate within the prescribed dimensions. Then the substrates were mirror polished by grinding on belt grinder for oxide layer removal, then on emery papers (1/0, 2/0, 3/0, 4/0),then the substrates were cleaned with soap and then washed with water, 9mm diameter zinc rod about 100mm in length was arranged as per the setting in vertical milling machine.

III. RESULTS & DISCUSSIONS

A. Microstructure Analysis:

At lower longitudinal feeds, prolonged plastic deformation time causes the formation of large volumes of plasticized metal. Therefore the forging effect may not be sufficient to consolidate the deposited metal, resulting in lack of bonding at some locations at the interface. The coatings get thinner for higher longitudinal feeds due to efficient distribution of plasticized metal assisted with application of axial load.

Fig 2: At 5X magnification at low rotational speed

The interface corresponding to higher longitudinal feed shows well bonded coatings with good bond integrity as shown in the figure 3.

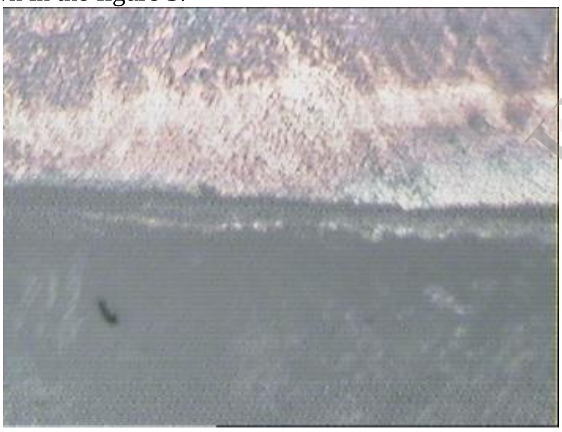

Fig 3: At 5X magnification at high rotational speed

During friction surfacing process, the regions near to the interface in both consumable rod and substrate experiences very high strain rates. The effect will be more pronounced in the consumable rod than the substrate, owing to the geometrical differences between them. More heat energy will be concentrated at the rod interface as the propagation of thermal energy will be slower due to size constraints. This leads to rapid softening and plasticization of near interface regions in consumable rod and subsequent deposition of plasticized metal on the substrate.

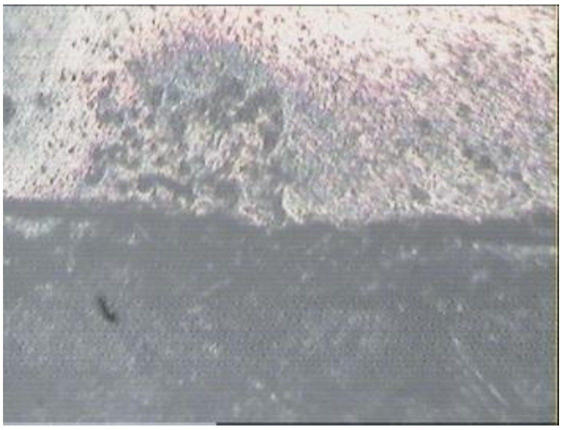

Fig 4: At 10X magnification at high rotational speed

Higher strain rates and higher temperature due to severe plastic deformation causes dynamic recrystalization and results in highly refined coating microstructure in the order of 0.01-0.05millimeters.

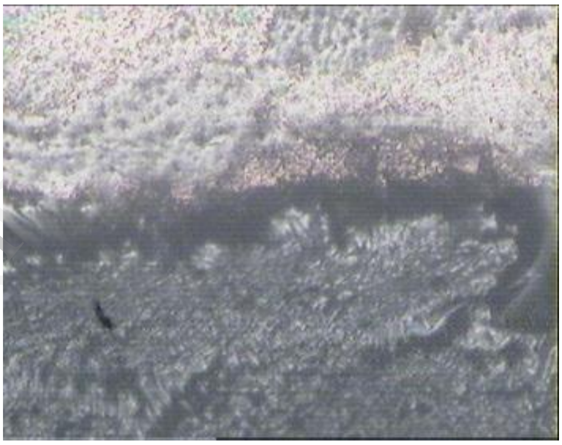

Fig 5: At 10X magnification at low rotational speed

The formation of fine grained wrought microstructure as opposed to the cast microstructure from fusion based coating technique is one of the major advantages of friction surfacing process.

CONCLUSIONS

For getting friction surfaced coatings with good bonding and required dimensions, the speed at which the substrate traverses is one of the critical parameters. Friction surfacing can be considered as an alternative for fusion based techniques in coating zinc on copper for corrosion protection applications, particularly for repair and reclamation. The solid state nature of the process retains or even improves the mechanical properties of the coating in addition to zero dilution. Zinc was found to be a well suited metal for use as a protective coating on copper substrate. On a substrate, a thick coating was formed which the range of thickness was measured to be 0.01-0.1 mm. The formation of the coating is in every case the result of the good diffusivity of zinc atoms in copper under the particular deposition temperature. The final oxidation product is zinc oxide, which also enhances the oxidation protection of the coating by passivating its surface.

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