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Influence of coating thickness during zinc deposition on copper by friction surfacing

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Abstract
Copper possess high thermal conductivity, highly durability and specifically applied to various field of applications like electrical and mechanical machinery equipments, excellent reproducibility and workability, apart these consistencies, it's quite cheap and it is one among the metals, available abundantly other than good conducting metals like silver. But it has got poor mechanical properties such as wear resistance and hardness. The main disadvantage is its resistance in aggressive environments which can be solved and sorted by the coating it with zinc to form ZnO. It is the best way 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 passivity the substrate from further oxidation. For this specific study, deposition of Zinc on copper plate by varying different parameters (i.e., longitudinal feed, speed) on vertical milling machine. The effects of longitudinal feed on the geometry and mechanical properties of the coated metals are investigated by various techniques and also the coating thickness from microstructure of Zinc coating on Copper substrates using moto software.

Keywords: Microstructure analysis, Coating thickness and vertical milling machine

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. 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 m8b-7material 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 [2]. 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 [3]. 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 by using optical microscope with aver cap software.

2. "Materials and methods"
2.1 "Sample preparation"
The copper was selected as substrate; substrates were collected from hot rolled copper strip by cutting it into 300x170x5mm size piece. For operating conditions, the substrate was cut into 3 plates with dimensions of 300x10x 5mm in size. Using scriber and ruler we marked 170x100mm space over the substrate & by making use of the tool, the surface of the substrate roughed 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, zinc rod of 9 x100mm diameter and length was arranged as per the. SM – II vertical milling machine.

2.2 "Experimental setup"
During machining process, the Zinc rod, kept rotating in clockwise direction to deposit the material on copper substrate it acts as a depositing tool as it is inserted into the spindle of the vertical milling machine set at a certain speed of 225 rpm - 310 rpm [4]. When rotational motion was given, friction developed against substrate by the zinc rod, starts depositing over the copper plate. Once, the consumable was sufficiently hot (red hot), and then the traverse feed was given to the surfacing consumable. The hot consumable material flows plastically over the substrate to form a thick coating process shown in Fig.2.

Fig 2: Surface coating using friction surfacing

2.3 "Coating thickness"
After coating Zinc rod on copper plates, the thickness of the coated material is study by using coating thickness gauge. Due to temperature and speed difference the coating thickness varies.

2.4 "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.

3. "Results & Discussion"
3.1 "Coating thickness Analysis"
Using motic software, we measured the coating thickness of Zinc deposit on copper, sample microstructure as shown in the microstructure below:

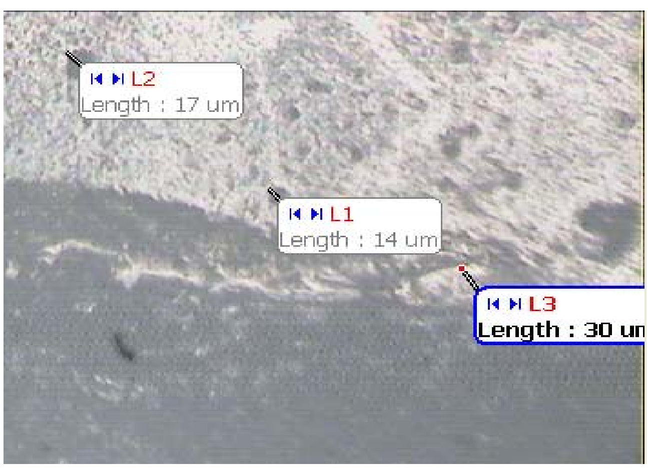

Fig 3: measurement of coating thickness at various points for 5X magnification at low rotational speed

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

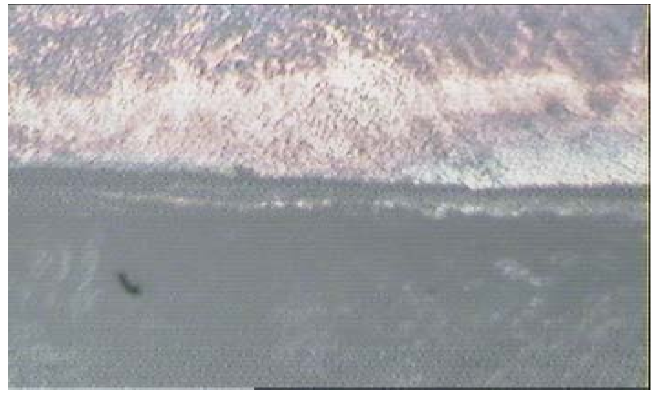

Fig 4: measurement of coating thickness at various points for 5X magnification at high rotational speed

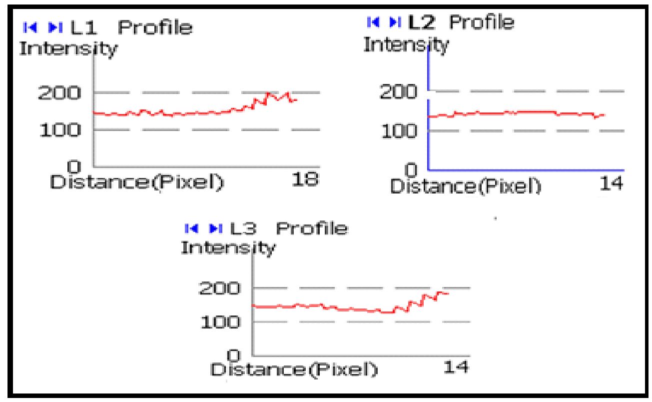

Fig 5: Intensity Vs distance graph at high rotational speed

The absence of spatter, radiation emissions or fumes makes friction surfacing a cleaner and more environmental friendly technology [5]
During friction surfacing process, the regions near to the interface in both consumable rod and substrate experiences very high strain rates. Friction surfacing enables a limited control over the deposited thickness and width, as coating geometry is determined by a relatively narrow range of process parameters [6]. 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.

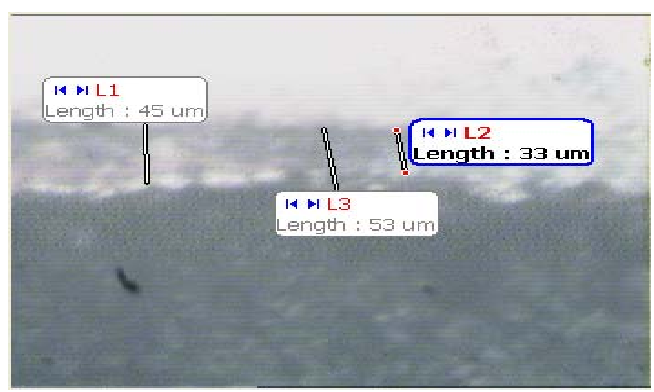

Fig 6: measurement of coating thickness at various points for 10X magnification at low rotational speed

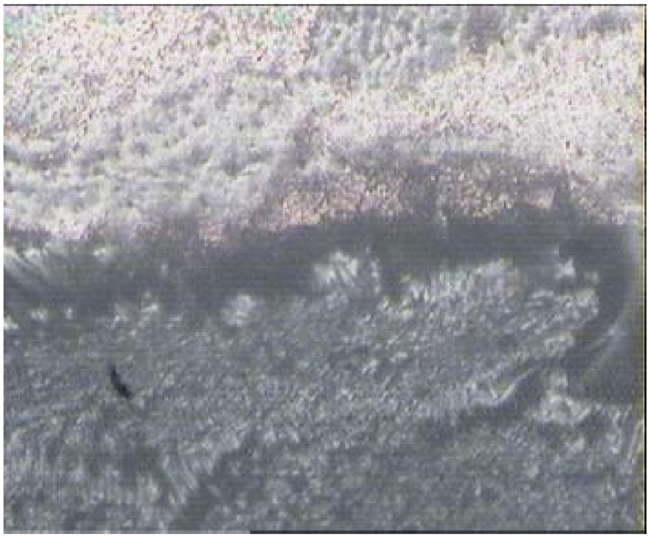

Fig 7: measurement of coating thickness at various points for 10X magnification at low rotational speed

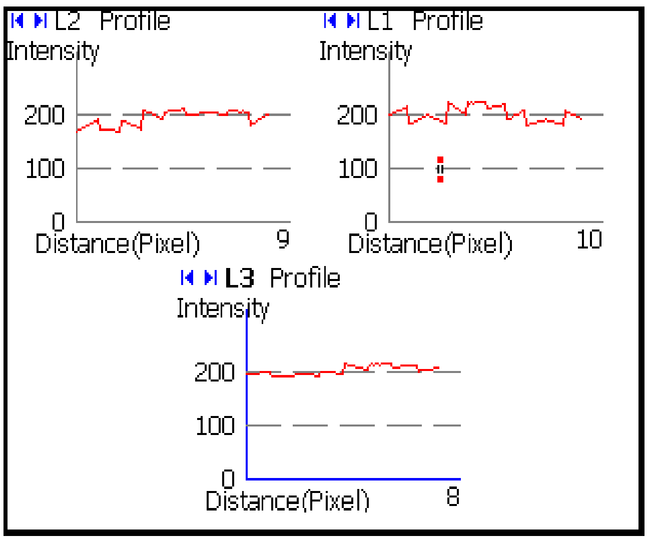

Fig 8: Intensity Vs distance graph to high rotational speed

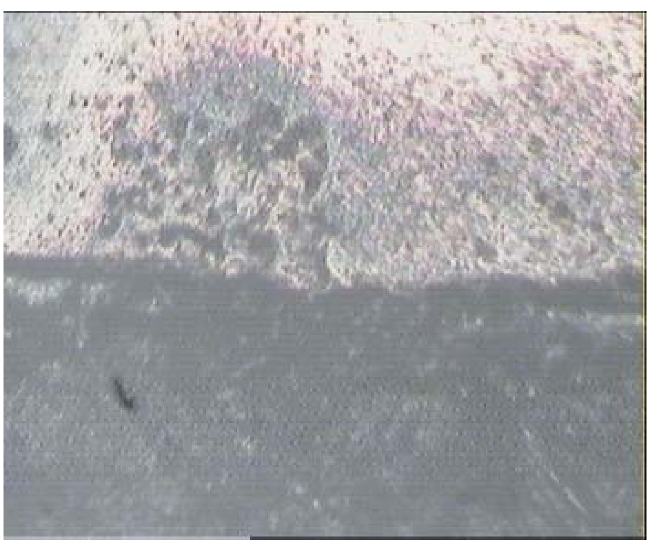

Fig 9: measurement of coating thickness at various points for 10X magnification at high rotational speed

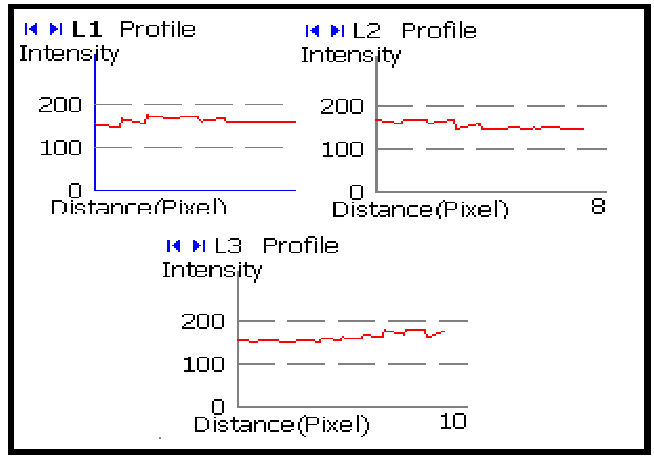

Fig 10: Intensity Vs distance graph to high rotational speed

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.

4. "Conclusions"

The solid state nature of the process, 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. It is being concluded from the microstructures for low rotational speed coating thickness was found to be in the range of 10 microns – 50 microns. Whereas for high rotational speed, thickness was measured to be in the range of 10 – 53 microns
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.

5. "References"

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