Experimental Study of Corrosion Behavior of Aluminum Coating on Mild Steel by Friction Surfacing: A Technical Review

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***Abstract*: Friction surfacing is a promising new technology for solid state metallic coating. Mostly, friction surfacing used to repair of engineering worm out parts and corrosion protection. The variety of materials combination in friction surfacing has successfully investigated in past decades. The present review paper describes the detailed description of alloy types and process parameter. Even though, successful alloy combination has been carried out, the control of process parameter is the promising challenge to the new research seekers.**

***Keywords*: Friction surfacing, mechanical tests, material types, microstructure.**

LITERATURE SURVEY

R. Sekharbabu et al.[1] emphasis about the D2 tool steel was coated over mild steel substrate using friction surfacing . To obtain fine coating, the process parameters for the friction surfacing were optimized. Microstructural study was carried out using scanning electron microscopy, optical microscopy and X-ray diffraction. Wear rate of the coated surface can be done using Pin-on-Disk wear tests. By decreasing the rotational speed of the mechtrode and increasing the substrate speed, results in thinner coatings. Hence, this type of coating exhibits better bond strength. The mixed effect of treated carbide particles and martensitic structure attains more hardness and wear resistance.

H. Khalid Rafi et al.[2] dealt with the solid state coatings of AISI 310 austenitic stainless steel is coated on mild steel substrate by friction surfacing process. The traverse speed effect on the structure, bonding uniqueness and mechanical properties of coatings are studied. Both axial load and rotational speed of the rod were kept constant and traverse speed was varied. Friction surfacing can be considered as an substitute for fusion based techniques in coating of stainless steel on low carbon steel mainly used for corrosion protection applications.

Margam Chandrasekaran et al.[3] done friction surfacing of (i) titanium, inconel, tool steel and aluminum rods over mild steel substrate material and (ii) mild steel, stainless steel and inconel over aluminum substrates. Tool steel and inconel were form a thick strong coating over mild steel but aluminum need to be deposited at high contact pressures. Titanium could not be settled under the tested conditions. Pretreatment can be given to Titanium alloy for better bonding. Control of process parameter (axial load, rotational speed, traverse speed) is required to obtain good coating quality. Mild steel can be easily coated over aluminium rather than stainless steel due to the lower hardness and plasticizing temperature.

Hidekazu Sakihama et al.[4] explained about the mechanical properties of AA5052 which was used as both consumable rod and substrate material. The deposit width increased with increasing friction pressure and reducing rotational speed of mechtrode. The deposit thickness became thinner when the rod was high revolution. The surfacing efficiency decreased with increasing axial load and rotational speed of mechtrode, but increased with increasing feed speed. The maximum tensile strength of deposits showed around 88.8% of the base metal of substrate. The Fig.1 shows the microscopic structure of tensile tested samples.

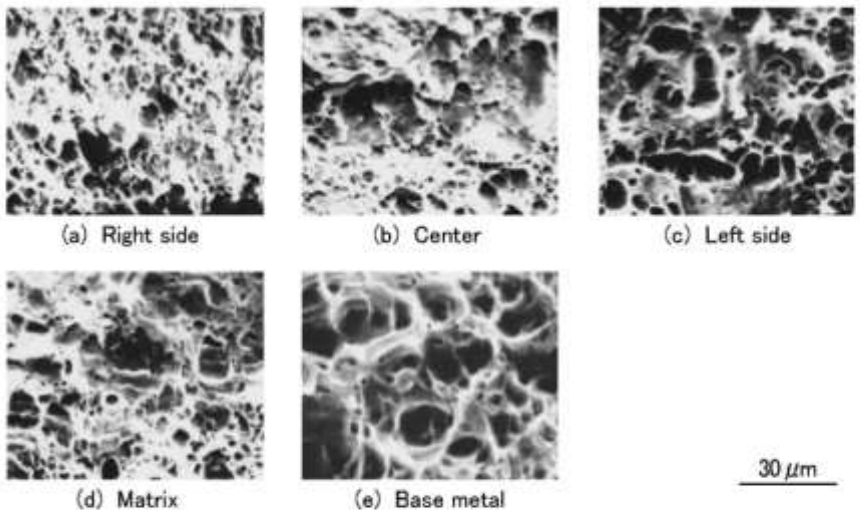

Fig. 1 Microfractographs of tensile tested specimens under conditions of friction pressure 40 MPa, rotational speed 33.3 s^{-1} and traverse speed 9 mm·s^{-1}.

The above structure was taken under the fixed parameter condition of pressure (40 MPa), speed of the rod (33.3 s^{-1}) and traverse speed (9 mm-s-1).

Takeshi Shinoda et al.[5] describes the surface modification process using frictional technique called friction thermo mechanical process (referred as FTMP). A mechtrode is forced to hit with the substrate plate while rotating. The friction heat, produced at the interface bonding between the rod and base material, makes substrate metal plasticized. The zone within 2-mm depth from face was polished microstructures, vanished cast defects and treated with hardness increment. The Fig. 2 shows the different grain structure.

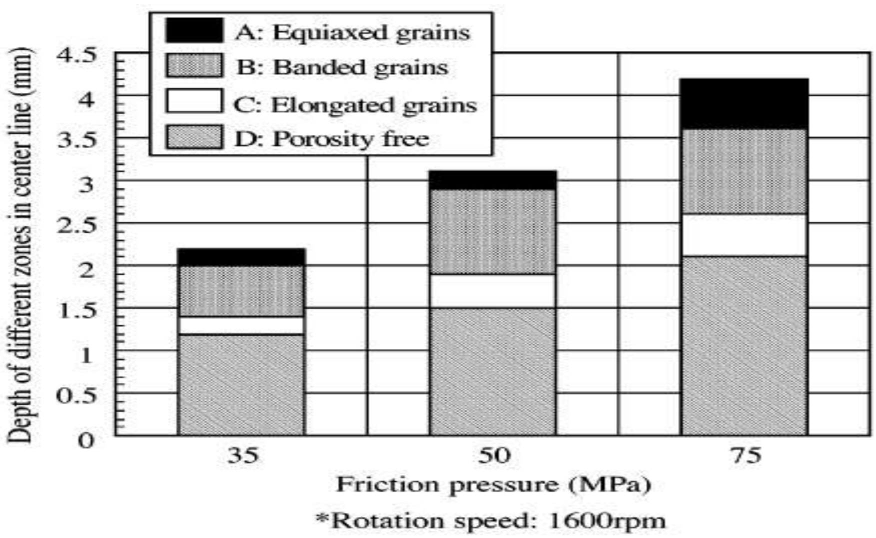

Fig. 2 Effect of frictional pressure on microstructures condition of modified zones by FTMP.

Ashok Kumar. U and Laxminarayana. P [6] explained friction surfacing of alumimium alloys over mild steel. The microstructure coating of AA 6082 over mild steel can be viewed in optical microscope. Mechanical tests include bending and hardness can be taken and compared with uncoated samples. The Fig. 3 shows the coating of aluminium over the M.S. plate.

Fig.3 : Coating of Aluminium over the M.S.plate

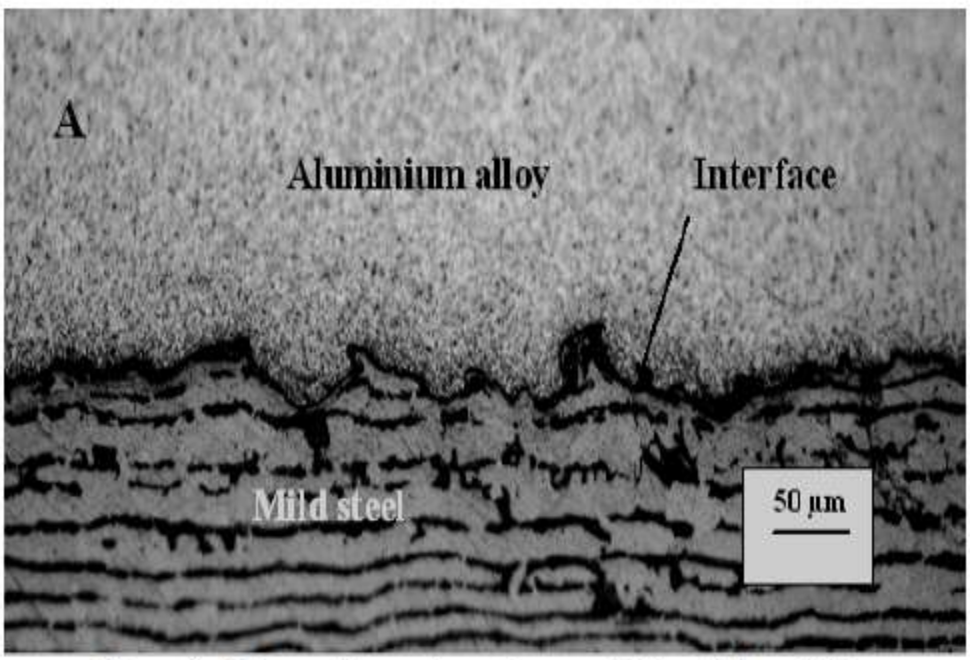

Fig. 4: The microstructure of the Aluminium coating over the Mild steel

The above figure shows the microstructural view of coating structure of aluminium over mild steel at interface. The result obtained was grain size 50 µm.

V. Sugandhi and V. Ravishankar [7] focused on the development of relationship for the prophecy of coating width, thickness of friction surfaced samples. Optimization of the model is carried out using design software to study the coating width and coating thickness. The results obtained explain that the developed empirical correlation can be applied to approximate the effectiveness of process factors for a given coating width and thickness. The developed relationships can be used to expect the coating at 95% confidence level. FS process parameters were sorted out using response surface methodology to achieve least thickness and greatest width. The optimum conditions are: axial force 14 N/mm^2, rotational speed 2500 rpm and traverse speed 16 mm/sec.

J. Gandra et al.[8] showed the wear characterization of AA6082-T6 over AA2024-T3 by friction surfacing. It also includes tensile and bending tests. Aluminium coatings were produced with a sound bonding of no porosity or intermetallic formation at the interface. An improved wear coating performance was observed due to the microstructure which identified under SEM. The heat produced during the friction surfacing process eleminates the T6 ageing heat treatment of the as-received aluminium consumable rod. Then, the hardness coating is obtained by the grain refinement due to dynamic recrystallization.

G.M. Bedford et al.[9] determined the thermo-mechanical process during friction surfacing of BM2, high speed steels, BT15 and ASP30 on plain carbon steel. The event that the surrounding substance and carbide experience the material pass from the coating rod to the base plate where coating formation can be demoted. There are notifications that secondary hardening is happened during tempering in general with traditionally hardened and tempered high-speed steels. The temperature at the friction interface has been measured to be 1020ºC.

M. Chandrasekaran et al.[10] were carried out with tool steel (AISI 01) and inconel 600 consumable rods on mild steel 1020 substrate in an argon atmosphere condition. Inconel strongly bonded with the substrate and there was proof of interfacial compound layer formation between the base material and coating. For tool steel coatings, a pointed boundary layer between the substrate and coating was examined by SEM (scanning electron microscope). No interfacial compound formed in tool steel coating, ensuing in poor adhesion to the base material.

H. Khalid Rafi et al.[11] friction surfaced Tool steel H13 on low carbon steel substrates. Mechtrode rotational speed and substrate traverse speed were changed, maintaining the pressure force constant. Coating microstructures were analyzed using SEM , optical microscopy and transmission electron microscopy. Hardness tests, bend tests and shear tests were conducted on coatings. Thinner coatings ensure higher bond strength than thicker coatings. Given consumable rod diameter and parameter settings that result in thinner coatings with stronger bonding between the coating and base material. Friction surfaced tool steel coatings exhibits good hardness.

Z. Lindemann et al.[12] explained the modelling of thermomechanical process in the area of friction welding of ceramics and aluminium. The modelling is done by of finite element method. The ceramics contains around 97% of Al_2O_3. The heat flux was customized in the repeated time improvement of numerical solutions by variable pressure on contact surface. The results of the simulation were evaluated to those achieved from the tests enhanced by means of a friction welding machine. Relationship between coefficient of friction and temperature has to be viewed for the welded materials.

Conclusion

It is obtained that from Friction surfacing, efficient bonding is achieved with no defects such as porosity, carbides and oxidation. The material properties such as bonding strength, coating width and other relevant factors will not change and there is an improvement as evaluated with Friction surfaced process. No material loss occurred in the Heat Affected Zone. Hence F.S is considered as more advisable process among the existing process used in variety range of applications. From the tests, it is concluding that the Friction Surfacing materials can be used professionally. Finally, material expenditure was achieved that Friction Surfacing is quite ready for action when compared to other surface coating technologies.

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