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Friction surfacing of AISI 316 over mild steel: A characteriation study

R. George Sahaya Nixon [a, b], B.S. Mohanty [c, *], R. Sathish [b]

[a] Department of Mechanical, Sathyabama University, Chennai 600119, Tamilnadu, India
[b] Department of Mechanical Engineering, St. Joseph's College of Engineering, Chennai 600119, Tamilnadu, India
[c] Department of Mechanical Engineering, SRM Easwari, Chennai 600089, Tamilnadu, India

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ABSTRACT

An attempt has been made with overlaying of stain-less steel on mild steel by the technique of friction surfacing. This investigation elaborates the excellence acquired by different combination of the process parameters used in friction surfacing specifically traverse speed of the cross slide, speed of rotation of the spindle and the uniaxial compressive load. Excellent overlaying has been obtained amongst the chosen materials. To which, the coating can be done with various set of process parameters. It has been observed that the bond strength of the coating was found to be at a maximum of 502 MPa by ram tensile test. Based upon this results the surface methodology was characterized with scanning electron microscope. For authenticating the results, the coated specimen was subjected to salt spray test. The bonding microstructure was characterized using optical microscopy and X-ray diffraction. Corrosion resistance of surfaced coatings was found to be more inferior to that of mechtrode material and greater with the substrate.

1. Introduction

Surface science and engineering truces with the exterior of the hardest material and it is sub restraint of materials science. The solid material includes a granular or lumpy mixture of material protected through an exterior surface and it is called outward phasing. The external surface of a solid interrelates with the adjacent atmosphere [1]. Friction surfacing is a superior surface alteration process, this technique was comparatively very simple, with which overlaying of the materials will be empowered after reconstruction of friction welding processes(Fig. 1). This process was much greater with related to resources of other surface modification processes and energy management [2]. Wear can be curtailed by amending the surface possessions of solids by surface finishing or by use of lubricants. Approximately the entire kind of materials, polymers and composites were able to be bonded on materials which are alike or unlike [3]. This phenomenon was obtained by creating the strengthened surface to the location in which it will be made to protect from wear and corrosion to prolong its life and also develop artistic manifestation of the substrates. This means that proper maintenances and the standby of scratched components are not continuously essential, limited maintenances of faults will be permissible, and that was achieved by friction surfacing of nonferrous materials [4]. In this process, tool steels which are contained with rigid stages cannot be easily formulated by deposition of materials. Here the melting process was not in bulk form and during the process of friction surfacing plasticization of materials due to dynamic re-crystallization has been highlighted [5]. It is promising to weld the different materials that can be mismatched or challenging to overlay the consumable by non dilution processes [6]. Related with these friction based processing techniques, by avoiding the deprivation on properties of material leads to lowering the heat input as well [7]. Bedford et al. reported, that the non appearance of melting leads to lesser residual stages and disappearance of dilution meanwhile the solidification shrinkage does not occur in dissimilar steels [8].

It consists of a rotating cylinder-shaped rod which is fed towards a plate with uniaxial compressive load performing at the same time. The difference in temperature is engendered amongst the plate and the rod. By the time of coating end of the rod is appropriately changed into the state of plasticization, the plate is

* Corresponding author. Tel.: +918300895132.
E-mail addresses: gsnixons@gmail.com (R. George Sahaya Nixon), profmohanty1@gmail.com (B.S. Mohanty).
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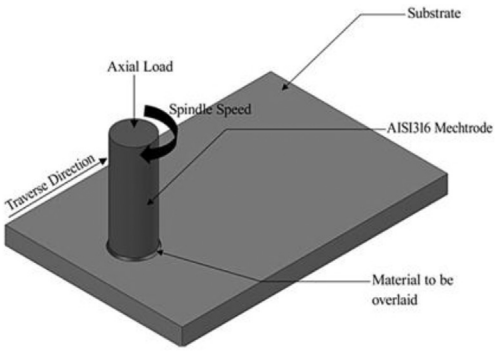

Fig. 1. Friction surfacing process.

intersected parallel with reference to the consumable rod [9]. As the traverse speed was initiated at a definite amount, the metal undergone dilution consumed over it. A close view of friction surfacing process was shown in Fig. 2. The axial force on the consumable, traverse speed on the substrate and rotational speeds on the rod is the primary process parameters for the aforementioned process [10]. The effect of speed of the cross slide over the dimensional variables, bond uniqueness of the interface and mechanical characteristics of the bond has been reported by Khalid Rafi H.et al. [11].

2. Materials and experimental methods

Mild steel plate of 10 mm thickness as a substrate was machined to 75 mm width 150 mm length. AISI316 stainless steel bar of 20 mm in diameter and 100 mm length was used as a coating rod. The chemical compositions of these base metals are shown in Tables 1 and 2, respectively.

The geometry of the material used for friction surfacing process prior to coating was shown in Fig. 3. Flatness of the consumable rod ends has been safeguarded by lathe machining. Surface grinding and milling was performed on the substrate to ensure flatness and the surface has to be restricted from oxides. Both consumable rod and the plate have to be washed with acetone earlier to surfacing towards reduction of the impurities during the process. Experimentations are piloted to define the operational assortment of the aspects, such as rotational speed of mechtrode, substrate traverse speed and axial force on mechtrode. The friction surfacing operation was done when the coating rod consumes about 30 mm from its length and the welding bead was at a distance of 50 mm to be overlaid. This process was done under the surfacing conditions of L9 orthogonal array as shown in Table 3.

The interfacial strengths of the coating and the substrate were determined by a tailor made ram tensile strength method. The specimen is loaded in UTM and the tensile strength values in MPa

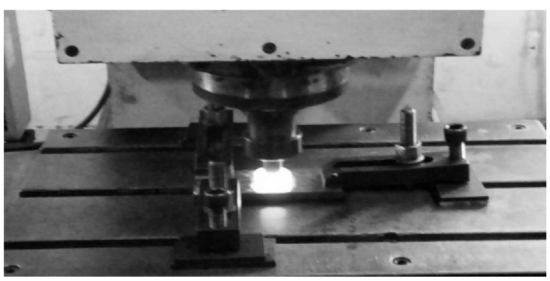

Fig. 2. A close view of friction surfacing process.

Table 1
Chemical composition of stainless steel AISI 316.

Material	C	Ni	Mn	S	P	Cr	Fe
%Composition	0.08	12	2	0.03	0.045	17	remainder

Table 2
Chemical composition of mild steel.

Material	C	Si	Mn	S	Fe
% Composition	0.10–0.20	0.40	0.60–0.90	0.040 max	remainder

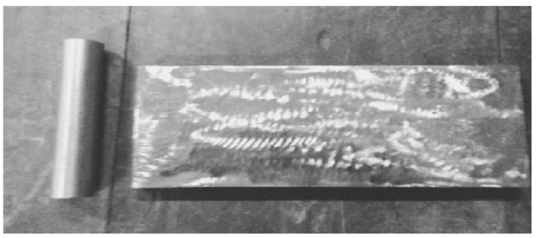

Fig. 3. Material geometry.

were measured by using the ram tensile test setup as shown in Fig. 4. Transverse segments were taken from the overlay were equipped for fractographic characterization for typical metallographic examination. X-ray diffraction (XRD) investigations were carried out by using A Philips X'pert PRO diffractometer at Cu Ka radiation for phase analysis. FS coated samples was carried out with XRD analysis. To evaluate the intensity over the bond, the d-ferrite quantity in FS coatings were found out by means of a Fischer-make polished specimens were electrolytically imprinted with 60% HNO_3 aqueous solution then the specimen were investigated by Leica-make optical microscope and an FEI-make SEM. AISI316 and mild steel were exposed to unfavorable chemical surroundings for the process of studying the durability and strength of AISI316-mild steel coatings under chemical resistance test. Salt spray tests of bonded specimen before and after acquaintance to 3.5% NaCl mist environment has been conducted.

The tensile strength of the friction surfaced specimens was determined to find their effective coherence. The ram tensile fixture was specifically designed as per MIL-J-24445 (SH) standard for estimating the tensile strength of the coating. The material coated and the substrate was made to lay upside down, coated surface facing the machining table and the substrate facing the tool. The Substrate was machined in the form of an inner circle or a hole to form an annular space between the substrate and the intact coating. Appropriate machining of the surfaces was made to facilitate effective clamping of the specimen on the designed fixture [12]. The inner circular area in the annular space was meant only for loading. The Universal Testing Machine was utilized to test the specimens. The specimen is loaded in UTM and the tensile strength values in MPa were measured by using the ram tensile test setup as shown in Fig. 4. The materials failed upon the action of regions where force is applied by push off tool. It is noticed that strong bonding between the materials has been obtained by applying tensile forces towards the materials. For the other samples the tensile testing were done to find the strength of the coating. It is observed that higher the axial load considerable rotational speed and traverse speed give more tensile strength and more ductility. Also when input process parameters are lowered it indicates lower tensile strength [13]. Further studies have been made with the sample of greater bond strength i.e. the specimen with the highest

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