

Characterization of Friction Surfaced Deposits on Low Carbon Steel

Ravi Sekhar S, Chittaranjan Das V, Govardhan D, Ram Subbiah

Abstract: Surfacing With Friction Is A Process Derived From Friction Welding With Advantages Over Commercial Fusion Welding Processes, With Solid Phase Bonding. Here An Experiment Is Conducted To Produce Friction Surface Coating For Three Different Materials Like Aluminum And Stainless Steel And Tool Steel M2 Coating On Low Carbon Steel By Friction Surfacing. The Aim Of This Work Deposition Of Different Materials Is To Identify The Feasibility Of Friction Surfacing And Industrial Applications, Testing Of Deposits For Quality Evaluation Are Carried Out.

Keywords: Friction surfacing. Aluminum, stainless steel, tool steel M2 on low carbon steel, process parameters and feasibility of friction surfacing

I. INTRODUCTION

The uses of friction based advances are expanding in different modern parts, for example, resistance, aviation, electrical, vehicle and numerous other mechanical areas. In this procedure, the parts are exposed to relative movement under strain so the frictional warmth created at the interface between faying surfaces, is used for joining comparative or divergent metals. Erosion surfacing is a novel procedure in strong stage welding system by methods for which comparative and divergent metals can be stored one over the other successfully. In erosion surfacing process, the consumable is as strong bar and is turned with fixed speed and propelling the equivalent under pivotal burden onto the substrate, creates the frictional warmth at the interface between faying surfaces.

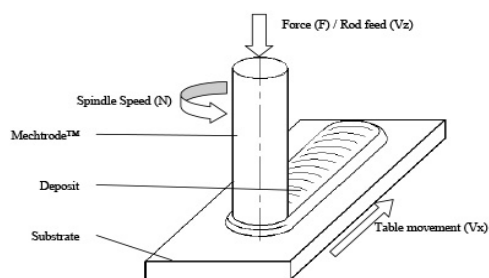


Fig 1: Friction surfacing

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Friction surfacing is the novel strong stage holding process that encourages metallurgical bonds, with applications in the regions of wear obstruction, security against erosion, homogeneous fixes to profitable parts and wanted warm/electrical properties. This procedure is additionally used to fix marine and oil pipes submerged [3]. Contact Surfacing is dependable and repeatable, material for some mixes of consumable and substrate, the store is free of porosity, breaks, slag considerations or weakening experienced with customary combination welding forms.

II. METHODOLOGY:

- (i) Impart desired properties to the base metals to be studied for choosing of the process parameters and Determination of process parameters for combination of stainless steel and tool steel deposits on low carbon steel material.
- (ii) Selection of process parameters and evaluate bond strength by adopting statistical design of experimental approach.
- (iii) Experiment to be carried out using the 2^3 factorial designs i.e., with three factors at two levels for each. Experimental design matrix indicating these eight treatment combinations.
- (iv) Primary testing and non- destructive tests to be carried out for evaluations of bond quality quantitatively and Effect of the process parameters on physical characteristics of deposit like surface height, width as well as surface roughness and mechanical properties like shear strength and tensile strength.
- (v) Analysis of deposit characteristics by micro hardness test and metallography and Special tastings such as corrosion and bend tests to be carried out on stainless steel deposits to design the manufacturing of pressure vessels for storage of corrosion liquids.

III. EXPERIMENTAL WORK

The materials such as Aluminum, stainless steel and tool steel M2 are deposited over the low carbon steel by friction surfacing. Tool steel AISI M2 with chemical composition (in wt %): is 0.791 C, 0.16 Mn, 3.83 Cr, 0.34 Si, 5.30 Mo, 1.82 V) of 10.5 mm diameter and 290 mm length, Aluminum rod having chemical composition in wt. %: 0.36 Fe, 0.03 Cu, 0.06 Zn, 99.55Al) of 12 mm diameter and 100 mm length and Stainless steel contains Fe - 67.50% , Carbon 0.07%, Nickel 10.5% and Chromium 18.0% with mass diameter 15mm and 290 mm length used as consumables. Low carbon steel used as substrate (Iron 99.18%, Carbon 0.21% by mass) of plate 12 mm thick and 450 x 200 mm size.

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Fig 2: Friction Surface Machine

The lower and upper levels of parameters are determined for getting thickness of 1.0 – 3 mm over low carbon steel deposit. Upper and lower levels of process parameters are evaluated by using mechanical and thermal properties of the materials. Since the temperature at the interface should attain closer to melting point in friction, using this relation lower value of rotational speed is identified. With specification of machine higher value of mechtrode is fixed and lower value of friction pressure is determined. Lower and higher levels of welding speed are determined to acquire the deposit thickness of 1.0 - 3 mm.

Statistical modelling is to minimize the trials required to optimize the friction surfacing conditions and to find the effects of interaction and effect of process parameters on the quality of the deposit. Hence the experimentation is performed by utilizing the 23 factorial designs i.e. with three factors at two levels for each. The table 2 represents the depositions of aluminium, stainless steel and tool steel M2 over the low carbon steel. The table 1 shows the process parameters and friction surfaced deposits on low carbon steel for various materials combination. The table 2 shows the mechtrodes on completion of one trial.

Table 1: Process parameters used for deposition on low carbon steel by friction surfacing.





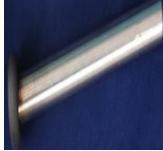

Material	Frictional Pressure (MPa)	Mechtrode speed (rpm)	Welding speed (mm/sec)	Friction surfaced deposits
Aluminium	8-12	471-558	67-92	
Stainless steel	26-49	1400-2500	78-190	
Tool steel M2	6-12	120-310	42-65	

Table 2: Process parameters used for deposition on low carbon steel by friction surfacing

Aluminum	Stainless steel	Tool steel M2
		



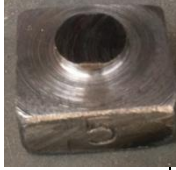

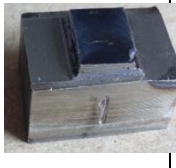

After each deposit, primary inspections are conducted to ensure to have bond with substrate. The same procedure is repeated for eight trials as per design matrix and tested specimens are prepared for investigation of its characterization after primary inspections. The deposits are made longitudinally with adequate spacing to get ready specimens for physical and mechanical tests.

IV. TESTING OF FRICTION SURFACED DEPOSITS

The characterization of the deposit is assessed through testing and inspection. The evaluation of the quality is broadly classified into non-destructive testing and destructive testing. Non-destructive testing is important to find the suitability of its applications in industry.

RAM test is conducted to determine the bond tensile strength and it is performed with specially designed fixture, which is used to hold the job and guide the ram. Tensile strength test is performed with 40-ton Universal Testing Machine (UTM). The specimens of tensile strength tests are represented in table 3 and range of tensile strength of friction surfaced deposits are shown in table 4.





Table 3: The specimens of tensile strength tests

Consumable	Ram tensile strength test specimens		Tensile strength range for eight treatment combinations
	Before test	After test	
Aluminium			4-18MPa
Stainless steel			307-584 MPa
Tool steel M2			60-164 MPa

Shear strength test is play important role for determination of its application in industry. The specimens are prepared from deposits of all treatment combinations according to the standard ASTM 264 to determine their shear strengths, with 40 Ton Universal Testing Machine (UTM).

The values of shear strength of stainless steel and tool steel deposits are shown in table 4.



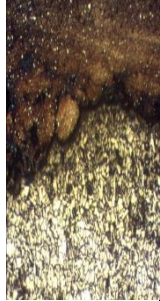
Table 4: The specimens of shear strength test

Consumable	Shear strength test specimens		Shear strength range for eight treatment combinations
	Before test	After test	
Stainless steel			74-184 MPa
Tool steel M2			25-76 MPa

V. METALLOGRAPHY AT THE INTERFACE OF FRICTION SURFACED DEPOSITS:

Metallographic test is the important to analyze the structural characteristics at the interface of surfaced deposits. By this, it is also possible to predict the behavior of the metal for a particular service condition. This test is performed as per the standard IS: 7739 Part 1 at the interface, towards low carbon steel and friction surfaced deposits. In determining metallography, specimens are ground flawlessly with motor driven abrasive belt. Glass polishing or emery polishing is also performed with series of emery papers and wet polishing operation is performed on polishing machine. Etching is done on the low carbon steel side with 4% nital solution. This solution resolves the ferrite into white shading and pearlite into dark, so that they are effortlessly recognized under the microscope with a typical magnification of 200 X.

Table 5: Metallography of friction deposits of aluminum, stainless steel and tool steel M2



Material	Aluminum	Stainless steel	Tool steel M2
Microstructure of friction surfaced deposits			

The metallography of friction deposits of aluminum, stainless steel and tool steel M2 are in table 5 respectively. The microstructure near the interface is useful to anticipate the behavior, performance and reliability of the deposit for a specific service condition with acceptable accuracy.

5.1 Bend test.

Bend test is conducted for aluminum and stainless steel deposits for producing containers to store corrosive fluids. The specimens used for bend test are shown in table 6 and these are treated qualitative tests. When viewed under stereo microscope and there is no separation of weld deposition, torn or cracked on the deformed surfaces. At 180o bend angle, a good improvement were been showed related frictional pressure and low welding speed.

Table 6: The specimens used for bend test:

Bend test of Aluminum deposits	Bend test of Stainless steel deposits
	

VI. RESULTS AND DISCUSSION

Dwell time of 5 seconds is required for aluminum and stainless steel and 30 seconds for tool steel M2 friction surfaced deposits. It depends on thermal and metallurgical properties of materials. It also concluded that proper welding speed is used during the process and belong to solid state welding process. Initially the dry friction between mating parts produces more heat, consumes more power and experience huge vibration, hence proper level of parameters are required to protect the machine.

The dye penetrate test is enough to assess the quality of friction deposits. specimens free from the cracks when tested by dye penetrate test. This test is performed to all specimens used for metallographic, corrosion, tensile strength, shear strength and micro hardness tests. The side bend test is important for the aluminum and stainless-steel deposits to judge the bond quality qualitatively which decides for industrial applications particularly to make vessels for corrosion materials.

The heat affected zone is a smaller amount in friction surfacing and hence further there wont be any requirement of heat treatment process, to relieve internal stresses developed like in conventional welding process. Metallographic examination is performed to know the micro structural changes that developed near the interface of deposit and substrate which create correlation between hardness and shear energy. Corrosion test is also performed for stainless steel deposits to find its applications in producing pressure vessels and pump bodies for handling and storage of corrosive materials.

VII. CONCLUSIONS

Experimental outcome indicating that the friction surfacing method is an alternative method for deposition of material over the other. It is also found that it is successful method for deposition of stainless steel and tool steel M2 onto low carbon steel.

In friction surfacing, the machine experiences large vibrations at initial stage due to presence of dry friction and high power consumed. Selection of process parameters at higher level is important as friction pressure bends the mechtrode at the forging temperature, rotational speed results in huge power consumption at initial stage due to dry friction and also it stalls the motor. Machine also subjected to huge vibrations and deposition will not takes due to higher welding speed.

In microscopic test, it is concluded that, there is intermixing of consumables such as stainless steel and tool steel M2 with low carbon steel due to hot shearing and forging. Hence good mechanical bond strength is obtained with interlocking. The physical properties such as width, height and surface finish of the deposit is different for different trials and depends on process parameters used. Height, width and surface roughness deposition was found to be more in initial stage and later it remains the same as the process continues.

From the analysis of regression equation of tool steel M2 deposits, it is concluded, there is an intermixing of consumable materials with substrate at the interface and it is due to hot rotational forging. The interface layer is intermixing of both consumables and substrate. The microstructure from the interface to low carbon steel indicating that the heat affected zone is decreasing gradually and remains the same, hence it concluded that there is a minimum distortion is obtained. It is also concluded that the suitable process parameters are identified and the generated heat sufficient to the deposit to form bond with substrate.

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