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Factors Affecting Friction Coating on Stainless Steel 304

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Abstract- Low carbon steels are widely used for structural applications because of its ease in fabrication and the moderate strength it posses. However, its pure corrosion resistance at normal atmosphere is a matter of serious concern.

I. Introduction

Fusion welding based coating techniques generally suffers from dilution and thermal spraying results in mechanical bonding rather than metallurgical bonding. Friction surfacing is a relatively new technology which is capable of producing coatings with zero dilution and good metallurgical bonding. This is attained because no melting is involved in this process.

Research so far has revealed that in friction surfacing the mechtrode force (F), mechtrode rotation speed (N) and substrate traverse speed (V_x) are of critical importance for the final quality of the coating and bond.

- Development of a methodology for in-process precision measurement of temperature, torque, bonding time, spindle rotation speed and force.
- Development of an empirical model involving process parameters V_x, F, N and coating quality state variables C_{bs}, Ct, Cw.

Fig. 1.4 Friction surfacing machine

II. LITERATURE REVIEW

M.Chandrasekaran, S.Jana carried out friction surfacing with stainless steel 304.

V.I.Vitanov, I.I.Voutchkov studied the three state variables, that reflect coating quality were considered as a subject for optimization and in this context a target for process parameter selection which are coating thickness, coating width, coating bond strength.

Louda showed the examples of thin coatings application in automotive industry and commercial. Thereby gave economic, ecologic savings and maintain its environmental stewardship in the global market

Tau V.R, Durodola B.M, Ajayi O.O, Loto C.A carried out the zinc deposition on mild steel with different parameters. Finally the coating surface examined with ion beam scanning electron microscope and x ray diffraction methods.

III. COATING APPLICATIONS

Use of thin coatings in automotive industry gives economic and ecological savings. This is evoking by reducing of weight of used construction elements and currently by increasing of their service life and with that connected elevating of nano materials manufacture qualities.

3.1 DECORATIVE COATINGS

Product range of decorative coatings covers technologies for the entire spectrum of decorative and functional surface treatment for various materials including steel, aluminum and even plastics. At the present time are applications plastics as well as metal, from car wheels to bumpers and door handles to radiator grills. Decorative coatings can be made from:

- Plating on Plastics
- Copper
- Precious metal

Plastic and plastic composite materials continue to be popular because of the way they combine the advantages of both worlds. Plastics are light, corrosion-free and can be formed to virtually any shape. Even complex components can be cost effectively produced in volume. A metal surface gives plastics a high quality, decorative appearance. This is why the advantages of plating on plastics are being appreciated in more and more industries.

The most popular type of decorative copper plating processes is Acid Copper. The high ductility of the acid coppers minimizes thermal expansion and flexing problems. Acid Copper is suitable for applications on zinc, brass and aluminium, bronze, steel, various other metal alloys, or most other commonly plated substrates. The copper deposit is easily buffed as is often required for intricate cast aluminium parts such as aluminium wheels. Acid Copper is versatile and very easy to operate. It is extremely bright, even in low current density areas, to make finding problems easier. In high current density areas the system is very resistant to burning.

Gold has the unique visual attraction and durability that makes it ideal for a wide range of applications, as gold is also an excellent conductor and almost totally resistant to corrosion and wear. It makes a reliable coating for technical and industrial purposes such as those in the electrical and electronics industry.

Fig. 3.1 Decorative coatings

3.2 FUNCTIONAL COATINGS

3.2.1 Corrosion Resistant (Zinc coating)

As functional coatings corrosion protection coatings for a global industry with high environmental demands are used. Corrosion protection coatings concerned with Zinc coating.

Due to the increasing expectations of consumers, the international automotive industry is required to extend vehicle warranties. Thus improvements in corrosion protection are becoming increasingly important. E.g. zinc-iron processes provide superior corrosion resistance even for complex shaped parts through uniform thickness distribution, and these highly bendable layers also allow machining. Zinc coatings enhance performance and extend component service life through improved corrosion resistance.

3.2.2 Wear Resistant (Nickel coating)

Nickel plating systems provides ideal wear performance for a variety of applications such as brakes, fuel systems, planetary gears, valve stems and steering components.

These processes offer a high level of flexibility to deliver just the right hardness and affinity to lubricants to reduce the wearing of highly mobile parts and to perform optimally as part of the total system of components.

Electroless nickel coatings are resistant to oxidation, chemically insensitive and in certain instances can be made non-magnetic and solderable. These products are not only used to produce wear resistant surfaces for a variety of auto-motive parts, they are also used to enhance tool life and overall quality for automotive manufacturing, especially in processing and stamping plants.

Electroless nickel coatings are highly resistant to corrosion, hard and resistant to wear, resistant to oxidation, chemically insensitive, non-magnetic and solderable.

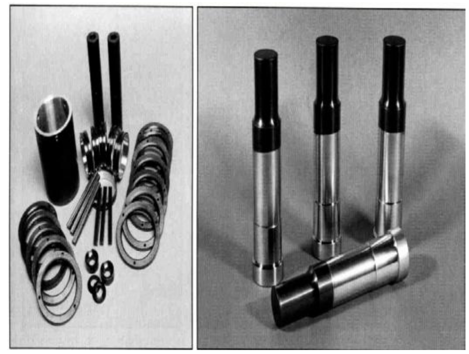


Fig. 3.2 Functional coatings

3.3 APPLICATIONS

3.3.1 Brake Calipers

Cast iron brake calipers are an important component within modern braking systems. For improved corrosion protection and enhanced appearance they are electrolytically zinc plated. Other cast iron applications include steering knuckles, which can be electroplated for enhanced corrosion protection.

3.3.2 Fluid Delivery Tubes

Fluid delivery tubing for automobiles like power steering, air conditioning as well as brake and fuel lines are usually made of low carbon steel and therefore require a corrosion resistant coating. For productivity reasons, many fluid delivery tubes are processed in straight conditions and are submitted to a post forming process. To achieve best inner tube corrosion resistance without any risk of particle formation even with alcoholic fuels, the parts can be electroless nickel and followed by alkaline ZnNi plated.

3.3.3 Fasteners

Fasteners - nuts, bolts, screws, washers, etc. this is the stuff that holds things together. The finish of a fastener is critical to its function. Most fasteners are coated to protect against corrosion and to achieve special properties such as controlling the amount of torque required to tighten a threaded fastener. With increasing demands for higher corrosion protection the use of ZnNi on fasteners is steadily increasing.

3.3.4 Shocks Rods

Piston Rods used for shock absorbers strut rods and gas springs need a hard chromium plated surface to provide excellent wear and corrosion resistance as well as a low coefficient of friction. The components are placed on vehicles at locations where they are subject to considerable environmental impacts such as corrosive salt-water solutions from de-icing of road surfaces and from stones hitting against them from the road.

3.3.5. Piston Rings

Piston rings provide a seal between the engine piston and the cylinder wall. Since the advent of hard chromium plating on these components the service life of the rings has been dramatically improved. Hard chromium provides excellent wear resistance and low coefficient of friction that is especially important in engine applications.

3.3.6. Engine Valves

Engine valve systems are hard chromium plated to provide excellent wear and a low coefficient of friction. The need to replace these components has been greatly reduced since the advent of this kind of surface coating.

3.3.7 Car Door Handles

The automotive industry demands ever reduced weight and resulting fuel savings, which is an important aspect in car manufacturing. By combining comparably low weight and production expenses of plastic parts with perfect metallic appearance, plating on plastics (POP) is the ideal solution.

3.3.8 Plated Aluminium Wheels

Worldwide, almost 50% of new cars are fitted with cast aluminium wheels. While the standard finish is likely to be paint or powder coating, there is an increasing demand for the bright nickel/chromium plated finish.

3.3.9 Fuel Injection Housing

Injection pumps used in diesel engines are mostly made of cast aluminium plated with an electroless nickel coating. Diesel cylinder liners are hard chromium plated to provide excellent wear resistance and a low coefficient of friction.

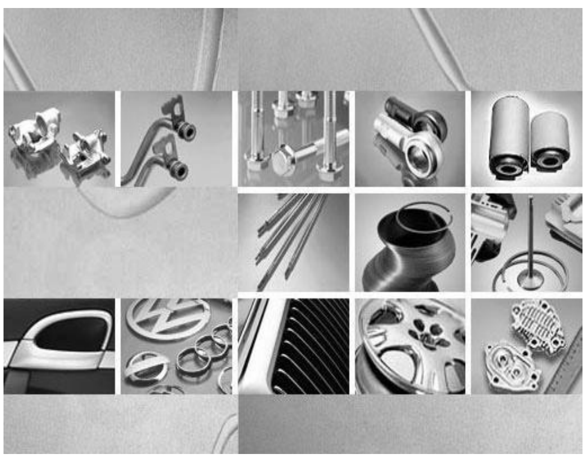


Fig. 3.3 Coating application

IV. FRICTION SURFACING

4.1 PROCESS DEFINITION

- It is defined as the solid state deposition process which involves rotating rod pushed against a horizontally moving plate
- It is used for wear resistance, corrosion resistance coating and for reclamation of worn engineering components.
- Axial load, rotating speed on the mechatrode and traverse speed on the substrate are the process parameters involved in this coating process.

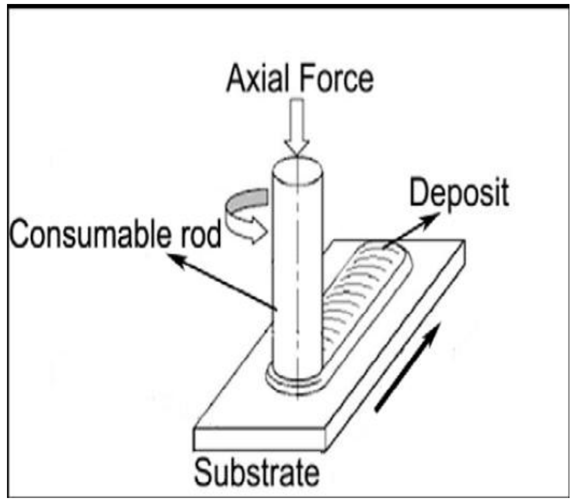


Fig. 4.1 Friction surfacing

4.2 MATERIALS USED

The following table summarizes the details of the materials which were used during friction surfacing process.

PROCEDURE

Step 1: Making to a proper dimension

Initially the mild steel plate was of 500*500*5 mm dimension. After cutting the raw material with gas arc cutter, it became 70*150*5 mm which is perfect for our electrolytic container.

Step 2: Rough finishing by emery paper

Initially the mild steel material got from shop is fully corroded. But with corroded surface electrolysis is not possible, so it must be removed. Emery is a type of paper that can be used for sanding down hard and rough surfaces. Even after hard rubbing with emery paper the mild steel plate is still corroded. Hence fine finishing with surface grinding machine is a must after rough finishing.

Step 3: Fine finishing with surface grinding

This is used to get a fine finish over the roughly finished surface obtained by emery paper. Surface grinding machine is being used.

Step 4: Applying ACETONE solution over the surface

A small contact time period is enough for atmospheric air to cause corrosion on a mild steel surface. Unlike in electro plating, friction surfacing process cannot occur after surface grinding process. So cleaning with acetone is necessary to remove corrosive particles in tiny holes of the surface.

Step 5: Corrosion free surface

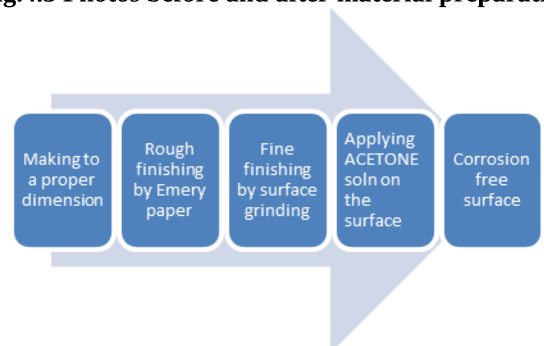
SET NO	Load (KN)	ROTATIONAL SPEED (RPM)	TRAVERSE SPEED (mm/sec)
01	10	800	1.2
02	12	1200	2.4
03	14	1600	3.6

Finally we get a mild steel plate without any corrosive layer. After the fine finishing process followed by acetone cleaning, our material is completely ready to use in machine bed for friction surfacing.

Fig. 4.2 Material preparation (Friction Surfacing)

	Object Name	Dimensions		Quantity
		Length (mm)	Thickness/ Diameter (mm)	(No's)
	Stainless Steel304	100	20	3
Emery Paper	Mica Sheet	100*100	-	3

Fig.4.3 Photos before and after material preparation



4.4 PARAMETERS INVOLVED AND THEIR EFFECTS

1.The load given on mechatrode in KN is directly proportional to the bonding efficiency. In higher loads the external energy required to form a coating is less.

2.The rotating speed given on mechatrode in RPM is directly proportional to the time taken for palstisation of metals. In higher rotating speeds plastisation occurs easily.

3.The traverse speed given on base metal in mm/sec is inversely proportional to the coating thickness. In lower traverse speed heat affected zone will be more. **SS304 on mild steel**

4.The load was kept constant; the other parameters like rotational speed and traverse speed were varied in steps to get the coating.

Table4.3 Work involved in friction surfacing of SS304 on M.S

Table4.4 Work involved in friction surfacing of SS304 on M.S through MINITAB 16.1.0 SOFTWARE

LOAD(KN)	ROTATIONAL SPEED	TRANSVERSE SPEED	TRAIL 1	TRAIL 2	TRAIL 3	MEAN
10	800	1.2	84.6	85.4	84.8	84.9333
10	1200	2.4	85.3	84.8	84.6	84.9000
10	1600	3.6	85.4	84.8	84.6	84.9333
12	800	2.4	64.5	65.4	64.8	64.9000
12	1200	3.6	64.4	64.8	65.3	64.8333
12	1600	1.2	64.3	64.8	65.3	64.8000
14	800	3.6	84.9	84.8	84.6	84.7667
14	1200	1.2	84.8	84.6	85.3	84.9000
14	1600	2.4	84.7	84.6	85.4	84.9000

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Welcome to Minitab, press F1 for help.

Taguchi Design

Taguchi Orthogonal Array Design

L9(3**3)

Factors: 3
Runs: 9

Columns of L9(3**4) Array

1 2 3

Results for: Worksheet 2

Taguchi Design

Taguchi Orthogonal Array Design

L9(3**3)

Factors: 3
Runs: 9

Columns of L9(3**4) Array

1 2 3

Results for: Worksheet 3

Taguchi Design

Taguchi Orthogonal Array Design

L9(3**4)

Factors: 4
Runs: 9

Columns of L9(3**4) Array

1 2 3 4

Results for: Worksheet 4

Taguchi Design

Taguchi Orthogonal Array Design

L9(3**4)

Factors: 4
Runs: 9

Columns of L9(3**4) Array

1 2 3 4

Results for: Worksheet 5

Taguchi Design

Taguchi Orthogonal Array Design

L9(3**3)

Factors: 3
Runs: 9

Columns of L9(3**4) Array

1 2 3

Results for: Worksheet 6

Taguchi Design

Taguchi Orthogonal Array Design

L9(3**3)

Factors: 3
Runs: 9

Columns of L9(3**4) Array

1 2 3

Taguchi Analysis: TRAIL 1, TRAIL 2, ... versus LOAD(KN), ROTATIONAL S, ...

Response Table for Signal to Noise Ratios
Nominal is best (10*Log10(Ybar**2/s**2))

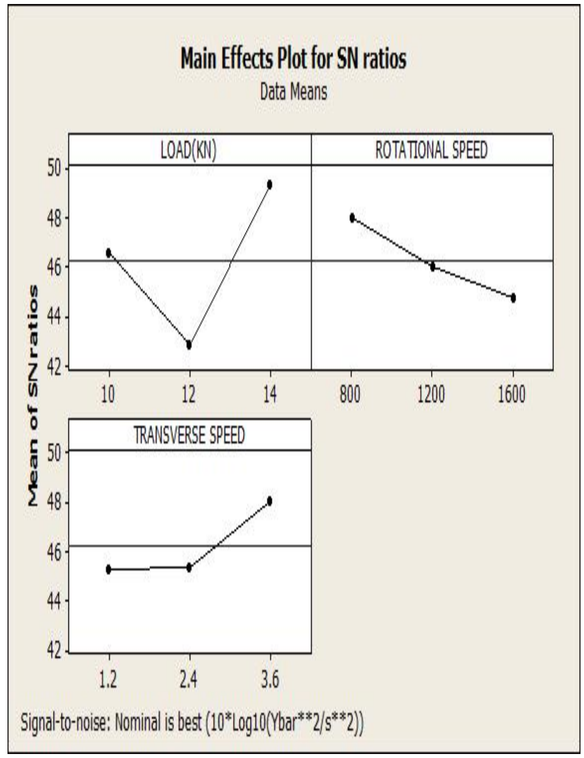
Level	LOAD(KN)	ROTATIONAL SPEED	TRANSVERSE SPEED
1	44.52	48.51	44.57
2	49.42	50.15	44.48
3	47.95	43.24	52.85
Delta	4.90	6.91	8.37
Rank	3	2	1

Response Table for Means

Level	LOAD(KN)	ROTATIONAL SPEED	TRANSVERSE SPEED
1	117.2	116.6	116.0
2	116.1	116.0	116.1
3	115.2	115.9	116.4
Delta	2.0	0.6	0.4
Rank	1	2	3

Main Effects Plot for Means

Main Effects Plot for SN ratios



Main Effects Plot for SN ratios

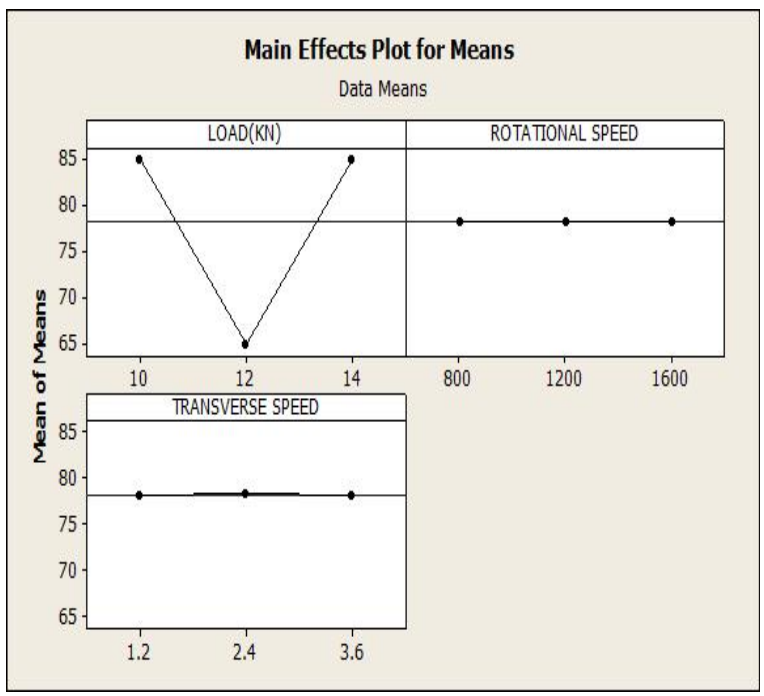
Taguchi Analysis: TRAIL 1, TRAIL 2, ... versus LOAD(KN), ROTATIONAL S, ...

Response Table for Signal to Noise Ratios
Nominal is best (10*Log10(Ybar**2/s**2))

Level	LOAD(KN)	ROTATIONAL SPEED	TRANSVERSE SPEED
1	46.61	48.03	45.29
2	42.81	46.01	45.42
3	49.37	44.75	48.08
Delta	6.56	3.29	2.78
Rank	1	2	3

Response Table for Means

Level	LOAD(KN)	ROTATIONAL SPEED	TRANSVERSE SPEED
1	84.92	78.20	78.21
2	64.84	78.21	78.23
3	84.86	78.21	78.18
Delta	20.08	0.01	0.06
Rank	1	3	2



Main Effects Plot for Means

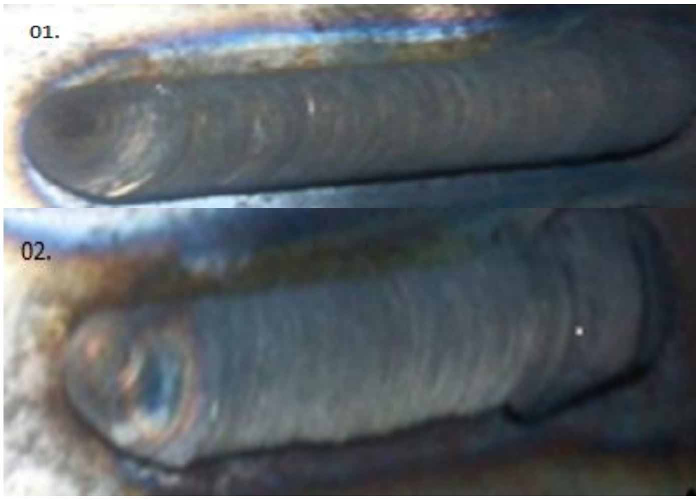


Fig. 4.5 Image of a M.S plate after friction surfacing using SS 304

V. CONCLUSION

For friction surfacing three different set of parameters were applied to get the minimum thickness. Hence it does not cause weight increases in coated substances. On mild steel plate both stainless steel 304 and stainless steel 316 has given a proper coating. But with copper as a mechatrode it forms flash rather than coating. Because of easy deformation of metal when copper rod is used, the coating will not form.

For electro plating, with time of contact of work piece in electrolytic bath as a parameter minimum thickness obtained. On mild steel plate coating successfully obtained by copper, zinc and nickel but not with stainless steel. Since pure metal only gives coating in electro plating.

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