Scope For Thermal Spraying Process In Paper and Pulp Industry

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SUMMARY

The aim of this paper is to present briefly the thermal spraying process, the selection criteria for the process and consumables. It highlights the ability of the process to effectively impart varied desired and specific engineering properties to the working surfaces of components.

Thermal Spraying is a process of applying protective coatings such as metals and ceramics to various surfaces by projecting molten particles with high Velocity to impact on the prepared surfaces. The application of the process is gaining rapidly in a number of industrial sectors and the paper and pu'p industry is an important one among them. Today the working surface property requirements have become more specific, exacting and sophisticated. A thorough knowledge of the process, consumbles, their selection and process parameters is inescapable for the right use of the process, and its actual control which in turn influenc es the coating quality.

This paper refers to various parts/components being reclaimed or manufactured in the paper and pulp industry by thermal spraying. The paper gives guidance on, where and when to choose a fused and unfused coatings. The thermal spraying technology is so varsatile that the coatings for many exacting and specific environment or service conditons may be obtained by proper selection of the process and the consumables.

INTRODUCTION

Thermal Spraying technology is gaining ground as one of the versatile tools available to apply a variety of coatings on almost any substrate for imparting specific, desired surface property. It is a surface coating process and can be applied cost effectively to a number of parts/components in the paper and pulp industry during m intenance replacements and even on original manufa tured components. It can improve the performance of a component in serivice.

The coating applied may be metallic or ceramic varying in thickness from 0.1 mm to several millimeters, depending upon function of the coating. A simple and cheap substrate which can meet the strength requirements can be coated with a wide range of coating materials to impart desired specific surface properties.

The process of thermal spraying consists of depositing metals or certain other materials in the form of a molten spray which solidified on impacting on the surface to form a dense and strongly adhering deposit. Briefly the method consists of melting the material to be sprayed with applied heat through fuel gas flame. electric arc or plasma and simultaneously projecting the molten particles with a high velocity air jet on to the prepared surface.

THE PROCESS

There are only two major steps in this process-proper preparation of the surface of the work and then spraying on ihe molten material under controlled conditions.

Surface Cleaning and Preparation

In this process, the bond between the sprayed coating and the substrate is mechanical. Proper surface preparation of the substrate before spraying is therefore of most importance. This directly influences the bond strength of the coating. To achieve a good sprayed coating, a right combination of some of the following pretreatment processes will be needed. The combination is to be determined by whether the component is new or in use needing maintenrnce, the nature of contamination of the working suaface etc

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(1) Degreasing
(2) Stoving
(3) Pre-heating
(4) Under cutting
(5) Threading
(6) Masking
(7) Grit blasting

For the details of the pretreatment contact should be established with theramal spraying contractors of repute.

Spraying

Thermal spraying comprises a group of processes in which finely divided molten metallic or nonmetallic material is sprayed onto a prepared substrate to form a coating. The sprayed material is orginally in the form of wire or powder.

The apparatus used consists of a spray gun not very different in size and appearance from that used in paint spraying. The spray gun generates the necessary heat for melting through combustion of gases, an electric arc, or a plasma.

The coating materials are heated to a molten state and propelled by a stream of compressed gas onto the substrate. As the particles strike the surface, they flatten and form thin platelets that conform and adhere to the irregularities of the prepared surface and to one another. They cool and accumulate, particle by particle into a lamellar, cast like structure. Two types of coatings are used depending on the application and service condition. They are 'fused and 'unfused' coatings. Fusing is achieved by a subsequent heat-treatment process after spraying.

FUSED COATING

FUSED COATINGS are widely used for hard facing of pump sleeves, conveyor screws, wear plates of wood chipper discs etc. where self-fluxing powders are used. By a post spray heat treatment not only the alloying of the sprayed material is accomplished but also the coating-substrate bond is Improved by diffusion process establishing a metallurgical bond. The powders usually used are Nickel or Cobalt-base alloys with high chromium content and may contain tungsten carbide as well. All contain silicon and boron to lower the melting point and produce the self fluxing action.

To obtain a fused coating, self-fiuxing alloy coatings are fused with an oxy acetylene torch, or by induction or furnace heating. The main requirement is to heat the coating and part to about 1050°C.

UNFUSED COATINGS are used in "as sprayed condition". The coating consists of a microporous lamellamer structure. The temperature on the substrate does not exceed 15°C. They are used when applying ceramic or carbide on pump parts and stainless steel, bronze, ~~copper etc, on~~ rolls, journals, digester parts and other parts. As the sprayed unfused coatings are porous in nature sealing of these coatings is necessary to avoid the under coat corrosion. Air Drying phenolic varnish is recommended for this purpose. An important example of this type of coating in paper industry is press rolls. These rolls are made of cast iron and are sprayed with austenitic stainless steel of 316 type.

Selection of Consumables

Proper selection of the material to be sprayed is equally important. A large number of proprietary consumables for obtaining a wide range of surface properties have been developed and are in use. They provide different properties and can be chosen according to the service conditions. Table 1 gives some consumables that are available, their nominal composition and their typical applications.

APPLICATIONS

The process is being used widely in paper and pulp industry. This is because. the process offers some unique advantages, some of which are :

(a) no heat distortion from processing.
(b) no curing requirements, and
(c) coating of any thickness can be applied.

Because of these and many other advantages, the process is gaining rapidly in importance in the paper and pulp industry. Three areas of engineering applications may be summarised as follows :

1. Reclamation of Worn Components

Thermal spraying offers a most effective way of reclaiming worn parts. Expensive parts need not be scrapped but may be built in surface very quickly at minimum cost. The reclamation is dependable and very often has a longer life than the original component.

TABLE I—TYPICAL APPLICATIONS OF SOME CONSUMABLES

Consumable/Process	Nominal Composition	Typical Applications
1. High chrome steel, (unfused coating); by arc or combustion	0.50 Ni-13.0 cr—0 35C–Bal Fe	Yankee Dryers, Glue Dryers, Dry Rolls, Digesters, Screw Conveyors, Fan blades Grip Jaws, Journals.
2. High chrome steel (unfused coating); Best quality obtainrd with plasma.	1)2.0Fe-8.5 Cr-2-2 Si-B-5. OM_o-7.OZ n-Bal Ni 0.2C-Fe	Yankee Dryers, Dry Rolls, Journals.
3. Austenitic stainless steel (unfused coating); primarily by combustion	12 0 Ni-17.0 Cr-0.08C-Bal Fe	Press Rolls, Kuster Rolls, Pump Shafts, Digesters.
4. Exotermic material self bonding Ni-Al (unfused coating used as bond coat); only by combustion	80 Ni-20 Al	Screw conveyors, Rewinder Rolls, primarily as bondcoat for not self bonding material such as stainless steel and high chrome steel. But also used as wear surface.
5. Molybdenum (unfused coating, self bonding); By combustion	99 90 M_o	Rewinder Rolls, Grip Jaws (Coarse Non-Skid coatings).
6. Ceramic chromium oxides (unfused coating); Best quality obtained by plasma.	92.0 Cr-oxide with Silicon and Titanium Di-oxide	Mechanical seal Ring, pump sleeves, pump shafts, screws to mono-pumps; chromium oxide is primarily used in severe corrosion environment.
7. Hard facing, self fluxing alloy (fused coating); by combustion	1) 2.5 Fe-16.0 Cr-0.5C-4 0-4.0 Si-B -3.0Cu-3.0 M_o –Bal Ni 2) 2.5 Fe-18-0 Cr-0 2 C-3 5–3.0 Si-B-40.0 Co-6.0 M_o-Bal Ni	Pump sleeves, screw conveyors, Face plates of wooden ship discs.
8. Heat Resistant Alloy (unfused coating); only by plasma	64.05 Fe-27.5 Cr-2.0 M_o-6 Al	Boiler Tubes (for fireside protection of black liquor recovery boiler tubes).

2. Mis-Machined Parts

In the same manner a mis-machined parts whether an expensive item or one of a batch of low cost production units can be salvaged rapidly and inexpensively.

3. New Surfacing

New components can have metal sprayed surfaces of alloy, steel, bronze, molybdenum, nickel, chromium boron alloys incorporated during manufacture. This enables inexpensive base material to be imparted surface properties of resistance to wear, abrasion, heat or corrosion or perhaps a combination, as the need exists.

Potential Candidats for Thermal Spraying

A numbers of parts are being sprayed and coated in maintenance and production in the paper and pulp industry elsewhere in the world. They are :

Press Rolls
Yankee dryers
Anode plates
Wear plates of wood shipper discs
Fan blades
Conveyor screws
Screws for monopumps
Digesters
Boiler tubes
Grip Jaws
Pump sleeves
Pump shafts
Housing for vacuum pumps
Mechanical seals
Structural Steels and Frames

Table II gives in brief the case studies of some components from paper and pulp industry, pointing out the part, the surface property requirement, the procedure used and the performance data of the surfaced parts.

TABLE 2 CASE STUDIES

Part name and coating function	Procedure and performance data
Anode Plate Copper is sprayed to restore proper electrical conductivity by filling eroded area around holes where the anodes are attached to the anode plate	Areas around hole are blasted with coarse aluminium oxide. The holes are then filled with carbon plugs for making and plasmasprayed with copper powder. After spraying, the carbon is removed and then the coating is finished with a spot facing tool flush with the original surface
Wear plates of wood chipper discs Plates are hardfaced with self-fluxing powder alloy to provide additional wear resistance. Plates are bent prior to spraying to compensate for the warpage during fusing.	The plates are blasted with sharp angular steel grit S20 and combustion sprayed with self-fluxing alloy in a thickness of about 1.3—1.4 mm Then fused in oil fired furnace. Coating thickness is about 1.0 mm as fused. No finishing required.
Fan blades of aluminium Hard chromium steel is sprayed to provide additional wear against erosion from abrasive particles	The blades are blasted with sharp angular steel grit S20 and are sprayed with 13% chromium steel in a thickness of about 1 0—1.2 mm. No finishing required.
Press rolls Diameter 1350 mm Length: 6.400 mm. Austenitic stainless steel of 316 type is sprayed on cast iron cylinders to provide a corrosion resistant coating that does not contaminate the wet pulp. In order to prevent dust being entrapped in the coating, the spraying, the spraying takes place in a special ventilated hood surrounding the spraysteam, removing the spraydust from the coating	The rolls are undercut, blasted with coarse aluminium oxide, preheated to 60—80°C and combustion wire sprayed with a bond coat of nickel-aluminium (0.1 mm) and with intermediate coating of high chrome stainless steel (1.5-2.0 mm) and top-coat of austenitic stainless steel (2.0-3.0 mm). Coating is sealed with phenolic varnish before machining and grinding.

Partname and coating function	Procedure and performance data
Pump sleeves of stainless steel used in thick stock pumps. Sleeves are hardfaced with self-fluxing powder alloy to provide additional wear resistance over gland packing area.	The sleeves are undercut and blasted with coarse aluminium-oxide and combustion sprayed with self-fluxing alloy in a thickness of about 1.5-1.8 mm. Then fused during rotation with oxy acetylene torehes and ground.
Seal mechanical seal, endface. Rings of stainless steel or titanium are coated with ceramic to provide additional resistance against extreme corrosion and adhesion wear,	The rings are undercut and blasted with coarse aluminium-oxide and plasmasprayed with chromium-oxide in a thickness of 0.5 mm. (No bond-coat is used to eliminate under-corrosion). Coating is sealed with phenolic varnish before grinding and lapping.
Screws for "Monopumps"	The screws are restored on the worm by welding and then blasted with coarse aluminium oxide and plasma sprayed with chromium oxide in a thickness of 0.5-0.6mm. Coating is sealed with phenolic varnish before being polished with fine abrasive paper.
Grip Jaws A coarse coating of a hard corrosion resistant alloy is applied in order to obtain a non-skid and non-contaminating coating.	Jaws are blasted with coarse aluminium oxide, pre-heated ro 60-80°C and combustion sprayed with a bond coat of nickel-aluminium (0.1 mm) and a top coat of high chrome steel (0.6-0.8 mm). The top coat has to be coarse sprayed and used "as-sprayed".
Boiler Tubes A heat and corrosion resistance alloy is sprayed for fireside perotection of black liquor recovery boiler tubes (carbon steel tubes)	Tubes are thoroughly cleaned and blasted with angular steel grit. Then plasmasprayed with a Fe-Cr-Al-M_o material in a coating thickness of about 0.6 mm.
Digesters Inside spraying of carbon steel digesters. Sprayed to retard corrosion action of pulp liquor and abrasive action of wood chips and sands.	Usually sprayed in the mid-section of the digester. Sprayed area has to be thoroughly cleaned dryed and blasted with steel grit. Then combustion-sprayed with 0.8—1.0 mm thick coating of high chrome steel or an intermediate coating of high chrome steel and a top coat of austenitic stainless steel. Coating ought to be sealed with silicon-aluminium paint.
Yankee Dryers Sprayed on site. The coating is applied to the dryer surface to replace cast-iron material lost by wear or grinding. The coating may be a full face or a build up of worn edges.	The cylinder is undercut, blasted with angular steel grit and arc or plasma sprayed with high chrome steel. Coating thickness 1.0—2.0 mm. To obtain high finish the coating is finished by belt grinding. As a plasma sprayed coating is denser than arc sprayed, the plasma coating has a better thermal conductivity & production performance.
Screw Conveyors Screws mainly used for feeding bark are hard faced either with sprayed and fused coating or with unfused coating of nickel-aluminium.	The persure side of the screws is blasted with coarse aluminium oxide preheated to 60-80°C and combustion sprayed with self-fluxing alloy in a thickness of about 1.5 –1.8 mm. Then fused with oxy acetylene torches. If fusing is a problem spray an unfused coating of Nickel-Aluminium in a thickness of about 1.0 mm. No finishing required.
Structural Steel Machine Frames Pump Housings In order to obtain a coating with high resistance against mechanical damage and corrosion a metallic unfused coating is sprayed as a base for paint.	Blast with angular steel grit or coarse aluminium oxide and combustion spray zinc-aluminium in a thickness of 0.08—0.10 mm. Then seal the coating with a vinyl based paint or any other sealer which is passive to the metallic coating. The sprayed zinc-aluminium is an ideal base for paint and eliminates undercorrosion.

VARIOUS PROCESS

Ther are four thermal spraying processes, They are :

1. Combustion spraying of wire (Metallizing)
2. Combustion spraying of powder (metal or ceramic)
3. Arc spraying of wire (metallizing)
4. Plasma spraying of powder (metal, ceramic and carbides)

The selection of the particular process is guided by the characteristics of the coating.

For example plasma spraying is used for spraying of dense, strong ceramic coating on seal rings, pump sleeves and pump shafts requiring dense ceramic coatings with high resistance against severe wear and corrosion. It is also used for spraying hard tough coatings of tungsten carbide on knives and fan blades, and for high temperature oxidation resistance coatings on boiler tubes in recovery boiler pans. Similar criteria determine the choice of the other process.

CONCLUSION

Thermal sprying is a proven versatile method and can be used to provide corrosion protection or to produce a surface with particular engineering properties.

Thermal spraying offers a most effective way of reclaiming worn parts and imparting in the first instance in manufacture special surface properties. This saves not only materials but also costs. Capital costs for new parts can be reduced by innovative use of the process. The cost of down-time and loss of production during maintenance and repair work can be reduced. The cost of buying oxpensive spares and keeping them in stock can be minimised.

This technology can also be used to improve the electrical conductivity of a contact surface.

Thermal spraying technology is a very potent tool which enables very thin to thick high duty coatings to be accurately applied for meeting a wide range of exacting and severe service conditions.

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