Thermal Spray Coatings in the Printing Industry

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MATERIALS & PROCESS TECHNOLOGIES

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INTRODUCTION

Thermal spray technology is over 100 years old. Currently, the North American market for services is over $1B. Principal uses for thermal spray coatings are in the Aerospace, Power Generation, Medical Implants and General Industrial markets. The Printing and Converting Industries are in the latter category and are estimated at approximately $30-40MM. In the printing and Converting market, thermal spray coatings are used for traction control, analox rolls, electrical resistance, wear and corrosion resistance and as a carrier for self release coatings.

We will describe the three most useful thermal spray technologies for the Printing and Converting industries, discuss the types of materials that can be applied including self release coatings and sealers and conclude with a discussion of the typical roll applications and materials used.

HOW THERMAL SPRAY WORKS

Thermal spray technology is a “line-of-sight-process.” Thus, it cannot generally be used to coat into bores or holes unless the depth of the coated area is equal to or less than the diameter of the hole or bore.

Basically, thermal spray coatings use a heat source generated by an electrical arc, combustion of a gas or liquid or recombination of an ionized gas and excited electrons to generate a temperature sufficient to melt or partially melt a material. Droplets formed when the material melts are propelled by a gas stream onto the surface to be coated, droplet-by-droplet, until a sufficient thickness is obtained to give a working coating suitable for the application. Coating thicknesses can be as small as 0.002 in. to as thick as 0.250 in. depending on the technology used, the application requirements and the materials being deposited.
USEFUL TECHNOLOGIES

As a practical matter for the Printing and Converting industries, there are three useful thermal spray technologies:

- Twin Wire Arc
- Plasma Spray
- High Velocity Oxy Fuel (HVOF).

Generally, the following characteristics are found for the coatings applied using the three technologies:

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<th>TECHNOLOGY</th>
<th>BOND STRENGTH</th>
<th>POROSITY</th>
<th>APPLIED COST</th>
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<tr>
<td>WIRE SPRAY</td>
<td>Moderate-High</td>
<td>High</td>
<td>Low</td>
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<tr>
<td>PLASMA</td>
<td>Moderate</td>
<td>Moderate-low</td>
<td>Moderate</td>
</tr>
<tr>
<td>HVOF</td>
<td>High</td>
<td>Very Low</td>
<td>High</td>
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Wire Spray uses two electrically conductive wires which are brought together in a nozzle and allowed to contact each other. Contact produces an arc which melts the wires with the resulting molten metal droplets propelled onto a surface with an atomizing gas to form a coating. Air or an inert gas is used to atomize the particles. Since the atomizing gas velocities are relatively low, Twin Wire Arc coatings tend to have lower bond strengths, porosities in the 5-7% range, some unmelted particles, high oxide contents and a layered appearance.

Plasma coatings are formed when a non-transferred arc contained inside a Plasma “torch or gun” ionizes an inert gas such as Ar, N or He. The resulting recombination of the ions and the electrons result in an intense arc or flame front with temperatures as high as 15-20000 °F. Such temperatures are sufficient to melt all the metals and ceramics sprayed using this technology. Gas velocities and temperatures are higher than with a Wire Arc system resulting in higher bond strengths, lower porosities, moderate costs of application and relatively higher complexity in control and equipment costs.
HVOF technology uses a combustion source of gas such as H₂ or a liquid such as kerosene and oxygen in a specially designed high velocity “torch or gun” that accelerated the high pressure gases or liquid to velocities of 3000-5000 ft per sec, MACH 4-6. Gas combustion takes place in the “gun” combustion chamber and thus, a HVOF gun is in actuality a small rocket motor. Particles are axially introduced into this high velocity gas stream are readily melted and propelled at velocities of approximately 50% of the gas velocities onto a surface with both high thermal and kinetic energy to form a coating.

Because of the high thermal and kinetic energy of the particles, HVOF coatings have near theoretical densities, i.e. porosities of <1.0% are common, very high bond strengths, very low oxide contents, no appreciable unmelted particles and high costs because of the large amount of gases used.

**MATERIALS**

Materials that can be applied using the three thermal spray technologies described come in a wide variety of forms and chemistries and can be used as is or blended to form coatings with unique properties and microstructures.

Pure metals have chemistries ranging from Al to Ta, Zn and Zr.

Alloys of all the common materials such as carbon steel, stainless steels, duplex stainless steels, Ni, Co, Fe and Cu alloys are available.

Intermetallics such as WC, Cr₂C₃ and blends of the carbides with Co, Ni and NiCr, are readily available and are used individually as well as blended products giving coatings with unique properties not available as wrought product forms.

Ceramic materials such as Al₂O₃, Cr₂O₃, TiO₂, ZrO₂ and solid solutions of these oxides as well as MgAl₂O₄, Al₂O₃-SiO₂ and ZrO₂-SiO₂ are available for a wide range of applications.

Blended materials sourced as powders can be used and applied by thermal spraying to develop unique properties such as very wear and corrosion resistant materials with high tolerance for impact by large particles or bending moments in long thin shapes such as rolls or cylinders.

Sealers are used on some coatings and at the ends of coatings where the coating and substrate meet to prevent corrosion undercutting of the coating. Sealers MUST be able to completely penetrate the pores of the coating. Sealers that don’t will sit on the surface and eventually wear away causing coating failure by undercutting by corrosion product under the coating.
Even HVOF coatings must be sealed at the coating-substrate interface to prevent undercut corrosion at this junction.

Self Release coatings must also penetrate into the pore structure of the thermal sprayed carrier and use the carrier to protect and prolong the life and property of the self release coating material. Some commonly used self release coatings do not retain their properties when subjected to mechanical damage and are thus not useful for long periods of time. Materials typically used are fluorocarbons, silicones and other proprietary products which are non-adherent to inks, adhesives and lint.

COATING PROPERTIES

Coatings are generally designed for a specific set of properties. Coaters or the end customer may design the coating to have properties “skewed” to one end of a range to provide something specific in a particular property for an application.

One downside of this effort is that other properties will be compromised and this needs to be taken into account when specifying a coating. It is therefore incumbent upon the customer and the coater to openly discuss the normal and unusual operating conditions when specifying a coating for an application. Failure to do this may result in less than satisfactory coating results in operation.

PRINTING AND CONVERTING APPLICATIONS

IDLER ROLLS

Idler rolls need to be free spinning, especially as web speeds continue to increase. Roll substrates for these applications can be Al, steel and composites. All can be thermal spray coated by competent coaters. In addition to being free spinning, idler rolls should be resistant to ink, adhesive and lint accumulation and transfer.

Coatings used on idler rolls to prevent/reduce ink, adhesive or lint adherence include silicone sleeves and coatings, fluorocarbons and hard coat anodizing. All of these are subject to damage from tools and wear causing adherence of ink, adhesive or lint and damage to the web.

One coating system has shown long term resistance to degradation of its self release properties from these sources. Its resistance comes from a combination of a thermal sprayed carrier coating and a self release material on the surface and in the pore structure of the carrier coating.
ANALOX ROLLS

Analox rolls are typically plasma sprayed ceramic compositions which are subsequently engraved for supplying ink for flexographic printing applications. Ceramic compositions vary and are chosen for the ability to be ground to fine surface finishes and ability to hold tight tolerances when engraved. It is imperative that the ceramic be very low porosity and has no unmelted particles in its structure as sprayed.

GRIPPING ROLLS

Gripping rolls are used to drive the web and are designed with a specific surface finish to “grip” the web material. Coating materials vary widely for this application from stainless steels to very hard and wear resistant intermetallics such as WC. Surface finishes also vary widely from Ra of 200-300 to Ra of <100. What coating material and application technology are used to produce the coating will depend on the web material speed of the web and whether the web has other features such as closures, etc. which will affect gripper roll performance.

CORONA TREATER ROLLS

Corona Treater rolls must withstand a very harsh environment. High voltages, temperatures up to 150-200°C, high web speeds, web movement and ozone are all present.

Various materials are used to cover the high voltage rolls in the system. Silicone sleeves, glasses, tapes and thermal sprayed ceramics are all used. For all high performance applications, thermal sprayed Al₂O₃ with very high purity and ultra low conductive ion content is the most cost efficient material for the electrode coating. Recently, a new system comprising a new ultra high purity Al₂O₃ and a sealer for the small amount of porosity present in the ceramic has shown significantly improved dielectric strength over standard thermally sprayed ceramics.

While glass is also an excellent material for the application, it is limited in its application to steel roll substrates which become a burden in larger rolls due to weight and the need for larger drive motors and higher costs.
REPAIR AND OVERHAUL

Repair of rolls is wide ranging and cost effective. Thermally sprayed coatings can be removed by both mechanical and chemical means. Other coatings such as chrome place or copper can also be removed. Thermal spray build-up coatings can be used on old rolls to bring them back to dimension for final plating and finishing.

Thermal spraying can be effectively used to develop a surface finish on a low cost substrate that is much more economical than using solid alloy substrates. Dual coatings can be applied to a roll with a low cost build-up coating being used under a high performance working layer coating for the application to provide a most cost effective solution to badly worn or damaged rolls.

FINISHING

Thermally sprayed coatings can be finished using all commercial techniques. Grinding, buffing, polishing and lapping are all techniques that are commonly employed.

Surface finishes as fine as 1-2Ra can be achieved and even lapping to light bands can be done.
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