ENGINEERED COATINGS
A NEW APPROACH TO IMPROVED PRINT-SHOP PRODUCTIVITY

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To make a profit today, it is critical for printers to find new ways to reduce press downtime and improve equipment utilization and performance. Saving time and reducing waste have become necessities in today's highly competitive environment. When we look at decreasing downtime, we often talk about careful handling of press components, proper maintenance and the importance of cleaning. Each helps prevent premature wear or damage and insures the proper performance of the system.

Figure 1 Dialectric properties provided by coating for corona treater roll

There is another school of thought that merits consideration. Another approach can extend part life and actually improve the operational performance of the components, resulting in a system that operates even better than it was originally designed to. When faced with a worn machine part, most people say, "Toss it. We'll buy a new one." Sometimes, replacing the part is not the wisest alternative. Perhaps the part can be restored to its original OEM tolerances. Perhaps, in the process of restoring it, its operational performance may be improved, even beyond the capabilities of a brand new part.

The application of a specific coating to the surface of a part provides a means to custom-engineer the surface characteristics of the part without changing the base material from which it was made. There are a variety of materials that possess desirable surface characteristics, such as release from inks and adhesives, wear resistance, corrosion resistance, non-stick, slip, low coefficient of friction, static reduction and dielectric properties. These surface attributes can be conveyed to the base metal without re-design or re-fabrication of the part when coatings are applied to the part surface. Printers benefit when the desired surface characteristics of a material are properly matched with the "problem" areas. Materials applied to provide specific surface attributes are referred to as *engineered coatings*.

What if you could add life to worn press components? How much time could be saved if parts cleaned up easier? What if you could prevent inks and adhesives from sticking to press parts? How many thousands of dollars could be saved if parts that were worn were resurfaced (for a fraction of the cost of replacement) instead of replaced? These and other press maladies could

Figure 2 Release coating applied to rotary die prevents pressure-sensitive labels from sticking to the die.

be avoided if coatings with specific surface attributes were applied to parts, which would benefit from those attributes.

What Are Engineered Coatings?

Engineered coatings can be ceramics, cermets, metals or polymers, including fluorocarbons. In applications requiring multiple surface attributes, combination coatings can be applied to a given part. A ceramic-fluorocarbon composite coating, for example, would provide wear resistance from the ceramic as well as the release benefits and reduced coefficient of friction provided by the fluorocarbon material.

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Most engineered coatings are applied with one of the common thermal spray processes: wire arc, flame spray, High Velocity Oxygen Fuel (HVOF) or plasma. In each of these processes, the microscopic particles of coating material are heated to the molten state and accelerated toward the part. Upon impact with the part, the particles flatten, cool and harden. The subsequent impact of millions of microscopic particles forms a single, uniform coating layer several thousandths of an inch thick.

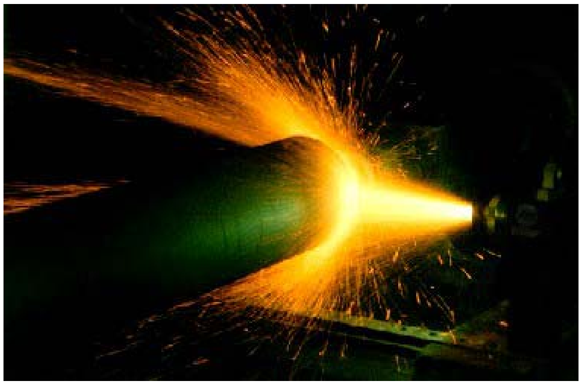

Figure 3 Wire arc build-up of roll face

Wire arc is used for building up metals or alloys. The metals come in wire form on spools. As they almost touch, the electrically charged wires arc, causing the metal from both spools to melt. The molten metal is atomized and driven by a stream of compressed gas onto the surface of the part.

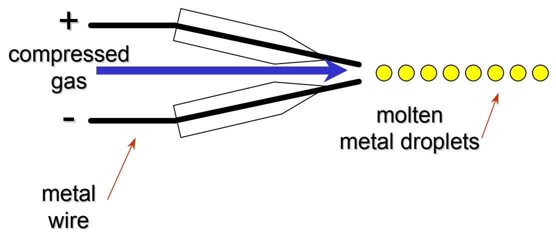

Figure 4 Wire Arc Spray Process

In flame spray, a fuel gas is consumed along with oxygen by a flame in a combustion process that melts and propels the coating particles. Even with the addition of compressed air, the particles move relatively slowly. As a result, they do not pack tightly, have higher porosity and are of lower quality than the coatings produced by other processes.

Figure 5 High Velocity Oxygen Fuel (HVOF) coating process

High-Velocity Oxygen Fuel (HVOF) is another combustion process. In this process, the combustion occurs in a chamber where tremendous pressure forces the coating particles at extremely high (supersonic) velocities through the nozzle. Because they impact the part with such tremendous force, they create an extremely dense coating with incredible bond strengths. HVOF is typically used for high-performance applications where coating density and bond strength are of paramount importance.

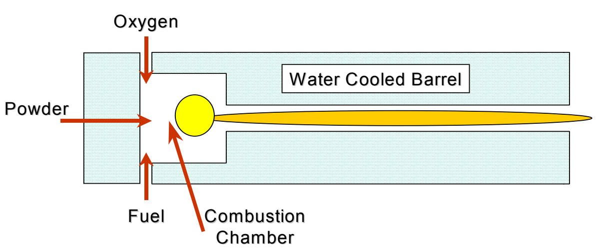

Figure 6 The HVOF process

In the plasma spray process, a high-voltage arc is struck between an anode and a cathode. A carrier gas fed through the resulting arc creates an intense flame with temperatures approaching 20,000 degrees F. This superheated gas expands and creates a high-velocity ion stream. Chrome oxide powder fed into the plasma becomes molten and is forced through the nozzle at high speeds.

Figure 7 Plasma gun applying coating to ID of land based turbine basket

Upon impact with the anilox roll (or any other part being coated), the microscopic particles flatten out like a snowball hitting the side of a barn. The heat from the particle is instantly transmitted into the part, causing the chrome oxide to cool and harden like lava from a volcano. As millions of molten particles go through this process, they form a coating of ceramic several thousandths of an inch thick. Because the particles are so small to begin with and then flatten out even more, it is impossible to differentiate a given "layer" of ceramic.

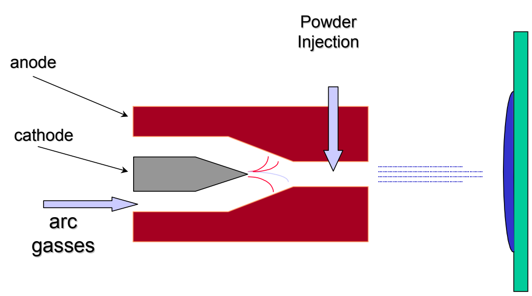

Figure 8 The plasma spray process

The Key Is Functionality

The specific coating process used for a particular application is based on requirements for density and bond strength, as well as the characteristics of the material being applied. While cost considerations also come into play, the overriding determinant is the functionality of the coating for the intended use.

Some applications have extremely stringent requirements for coating quality, density, tensile strength and other surface properties. Coatings for aerospace and land-based turbine power generation equipment must meet these stringent requirements. These specific coatings must be precisely applied, with quality confirmed through destructive and/or non-destructive metallographic analysis. The process and quality must be documented to ISO and military standards. Most people have never seen a turbine basket and have no concept of all of the complexities of the part or the engineered coatings applied to it.

Even though some specific applications may be exotic and complicated, the underlying principles for engineered coatings are very simple and illustrated in some common examples:

- Turtles, eggs and clams all have a hard shell for protection from predators, just as bark protects trees from animals, insects and the weather. The outer surfaces are harder and of higher density than the materials contained within.
- Downhill skiers know that applying a film of wax to the skis increases speed. By reducing the coefficient of friction, the skis glide over the snow easier.
- Some brands of cookware are treated with a non-stick coating for easier clean-up.
- Glass treatments reduce the surface tension of a car windshield so the rain beads up and rolls off, improving driver visibility.
- Non-skid adhesive tape provides traction in the bathtub to help prevent falls.
- The space shuttle's heat tiles provide a thermal barrier protection (insulation from intense heat) for the critical systems inside.

In some of these cases, the surface attributes of the object offer the requisite properties. In others, however, the properties required for the specific application are translated to the object by virtue of the surface material and the application process.

Flexo Coating Examples

Engineered coatings have been successfully used in flexographic printing for many years. The laser-engraved ceramic anilox roll is a prime example. The unique hardness and density attributes of the chrome oxide absorb laser energy, providing a cell wall structure that is much more durable and wear-resistant than chrome.

Most printers would agree that chrome rolls damage easily and wear out quickly because the foundation for a chrome roll is the soft, malleable copper layer beneath. Copper is used because it forms to the shape of the knurling tool. To provide a more durable surface, a microscopic layer of chrome is electroformed to the surface of the engraved copper. Even though chrome is much harder than copper (at about 900 Vickers), it is still no match for the environment encountered in a flexo press. Abrasive pigments are dragged along the roll surface at high speed by metal doctor blades. Pressure applied to the blades creates friction and causes the chrome to wear. Once the protective chrome is worn through, the copper is exposed and wears very quickly, resulting in rapid degradation of the cell-carrying capacity (volume).

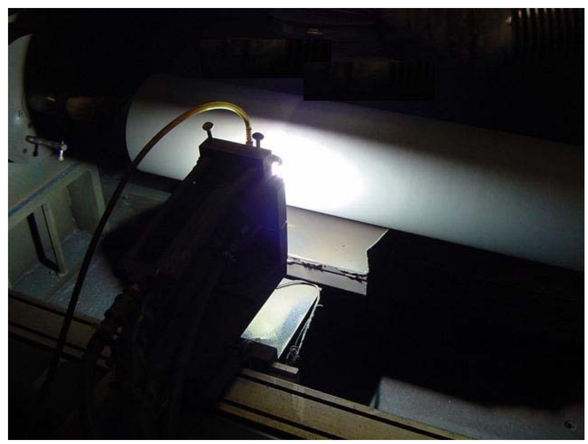

Figure 9 Chrome oxide ceramic applied to anilox roll with plasma flame coating gun.

To insure more consistent ink delivery over time, a more durable surface is required. Chrome oxide ceramic is a hard (approximately 1300 Vickers when properly applied), dense material that bonds to the steel base core through the plasma spray process. The quality of the ceramic is derived from a variety of factors, including the consistency of the powder particles. Oversized particles may not become molten. Molten particles may actually trap these unmelts on the roll surface, leaving air gaps known as *porosity*. Particles that are too small do not have the mass to maintain their molten state until impact. These will reharden in mid air and "bounce" off the roll surface. Contaminants in the powder create impurities in the ceramic coating.

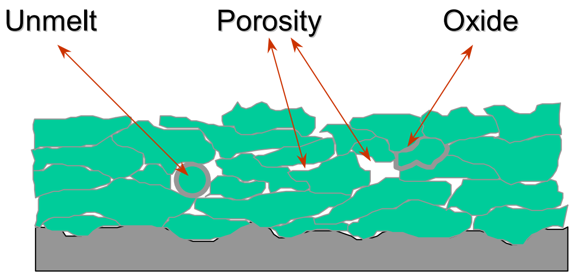

Figure 10 Diagram of a thermal spray coating

There are over 400 variables in the plasma spray process. The intensity and distribution of energy in the plasma flame derive from the condition, alignment of and gap between anode and cathode, as well as from the consistency of the carrier gas and the electrical charge applied. Cooling water circulated through the plasma gun helps prevent the deterioration of the metal components of the gun itself from the heat of the plasma flame.

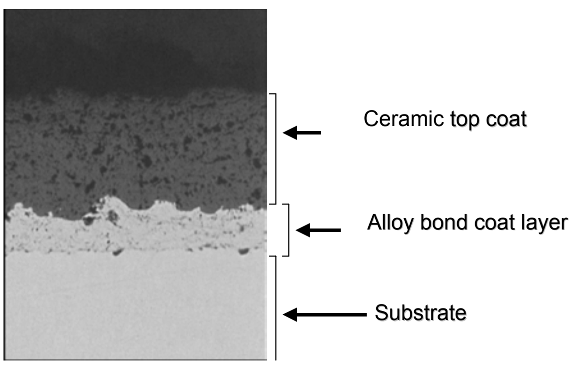

Figure 11 Cross section of a thermal spray coating.

The consistency and preparation of the roll surface prior to coating also plays a part. Deep gouges, grooves and machining chatter can translate through the coating to the engraving, creating a visible pattern on the roll that will transfer through the engraving to the print.

The coating then undergoes a series of post-process steps, one of which is the actual laser engraving of the surface. Critical performance attributes of the ceramic for this application are its density, consistency, surface finish and tensile strength.

Density and ceramic consistency are critical for insuring even absorption of the laser energy, as well as the uniform displacement of recast to produce cell walls of consistent thickness. Because the laser follows the contours of the surface it is engraving into, a post-grind polishing process is required that removes any chatter or other grinding marks and provides an extremely smooth surface.

Good adhesion of the ceramic to the base metal reduces the likelihood of delamination, or buckling of the ceramic. Because ceramic has only a mechanical bond to the roll surface, it's gripping power results from the roughness of the prepared surface. Properly applied, the bond strength of a ceramic coating can approach 5,000 psi. As the molten particles hit, they conform to any microscopic variations in surface texture. Once the ceramic hardens, the interlock of ceramic with the surface texture provides the tensile strength.

When you consider the long-term improvements in productivity and machine utilization, engineered coatings become a viable option for easier, quicker clean-ups and improved machine performance.

Another common example is the corona treater roll. The aluminum oxide coating applied to corona treater rolls enables printers to uniformly apply an electrical charge to the film surface to improve the adhesion of the ink to the web. In this particular application, it is critical that the coating have uniform dielectric properties. Any metal contaminant particles can act as a conductor, funneling the electrical charge through the web to ground. The release of the current through the contaminant would be strong enough to burn through the web at that location.

Figure 12 Coatings for idler rolls provide ink release, adhesive release, and traction for the web.

Other Applications Possible

Are there any other good prospects for engineered coatings? If you think about some of the daily headaches that you encounter, I am sure you can think of a few good prospects.

- How much easier would it be to clean up ink pans, idler rolls and doctor blade components if ink didn't stick to them and build up? A plasma sprayed composite fluorocarbon coating can provide a non-stick finish for easier, faster clean-ups without the need for harsh cleaning chemicals.
- Have you ever had a build-up of adhesive materials on an idler roll that resulted in a web break and roll wrap? A ceramic/polymer composite coating can provide improved wear resistance and traction, while inhibiting adhesives from sticking to it.
- Have you run across a situation where the web wanted to wander? The surface textures of thermal sprayed coatings can be altered to provide traction to the web when applied to idler rolls.
- What do you do if you have a good, serviceable anilox roll, but cannot use it because the journal surfaces are damaged or severely worn? These journals can be restored using a metal spray operation for a fraction of the cost of replacing the entire roll. A ceramic coating can also be applied to those surfaces, which would extend the life dramatically compared to a metal surface. The coating not only returns the surface to OEM tolerances, but provides improved wear and corrosion resistance, as well. This also holds for spindles, pump shafts and other situations where metal-on-metal contact causes premature wear of machine components.

Are these the only possible applications for engineered coatings? Certainly not! When you are faced with recurring problems in your operation, an engineered coating may be the answer. Look for examples where parts continually wear out and need replacement or instances when material sticks to rolls or other machine parts. Look for issues that waste a lot of time, such as press component wash-ups.

Depending on upfront costs involved, engineered coatings may not be a viable option in some cases. Some printers have found alternative approaches to resolve these issues. Wrapping various tape materials or Velcro® onto the surface of idler rolls, for example, can provide some short-term benefits. On the surface, these "quick fixes" appear to be cheap and relatively easy to do. The thing to consider, however, is that it takes time and effort to apply these short-term solutions each time they must be applied, and press downtime results each time the process is repeated.

When you consider the long-term improvements in productivity and machine utilization, engineered coatings become a viable option for easier/ quicker clean-ups and improved machine performance. Most people have heard the expression "beauty is skin deep." With engineered coatings, the beauty is in the improved productivity experienced from using them.

About the author…

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