Rx for Medical Surface Preparation: Corona Discharge Treatment

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It used to be that the best way to print calibrations on such items as plastic syringe barrels, medicine bottles, and caps was literally to expose the plastic to a flame, softening it just enough to allow the printing ink or labeling to adhere. With all the disadvantages inherent in such treatment, sometimes it seems hard to believe how widespread the process was but, as someone once said, "It seemed like a good idea at the time."

Problems with flame treating are manifold. The heat can easily distort the surface it's meant to treat if it is not calibrated and recalibrated frequently and exactly. Complex 3D objects may need to be manipulated several times in order to get the treatment into every corner or into closed areas, which can be a very tedious and time-consuming process. The gas/air mixture has to be closely monitored and frequently recalibrated to ensure any measure of consistency. In addition, the obvious hazard of working near an open flame is compounded by the risk of potentially noxious or toxic gases being produced by the flame and the material being treated. And yet, for a long time, flame treating was virtually all that was available.

Corona discharge treatment, on the other hand, not only eliminates the risks, costs, dangers, and other disadvantages inherent in flame treating, it adds a good deal of its own attractive benefits to the mix. It allows more flexibility in the treatment of an extremely wide variety of materials and products that are used in the medical industry whether it's syringe barrels or pill bottles to be printed on, catheter tubes to be coated for easier passing through veins, IV tubes to be treated for additional strength, or laminating protective film onto surgical gowns. The possibilities for corona treatment of materials are almost endless.

What exactly is corona discharge treatment? The simplest definition is that corona treating is an effective way to increase the surface tension of a material. Increased surface tension means that other materials, such as film or ink, will adhere better to the treated material. This is done by exposing the air at the material's surface to a high-voltage electrical discharge a *corona* that causes oxygen molecules in the treated area to break into ions that bond to the molecules on the surface of the treated material, or *substrate*. These ions are also extremely receptive to bonding with the material being applied to the substrate, whether the second material is ink, a laminate, or other coating.

Or think of it this way: most film and sheet materials have a smooth, slippery surface (*low surface tension*). Corona treatment, in effect, "roughens" the surface (raising the *surface tension*), allowing it to "grab onto" the inks, coatings, or adhesives being applied.

Corona treating is much better for 3D parts because it adapts much more easily to complex configurations. It can be easily applied to larger parts, measuring more than two inches wide, or parts that need to be treated on both sides or in hard-to-reach corners. Corona treating also eliminates all of the hazards of open flames. It dramatically cuts processing time, by eliminating virtually all of the manual manipulation required for achieving uniform treatment of some parts. And, by customizing the electrodes, corona treating of an entire part can be done in a single split-second operation up to four discharge heads can be positioned to provide complete coverage of the part's surface to prepare it efficiently for the application of labels, printing, or graphics.

Corona discharge treatment is a well-proven technique that has been in wide use for decades in industries producing packaging materials and plastic products with labeling almost anywhere that a material needs to be treated for more effective printing, labeling, or laminating. It is ideal for an extremely wide array of medical product applications, saving costs for both producers and end customers, creating a safer work and living environment, and enhancing the quality and safety of myriad end-products. Let's take a closer look at just how the corona discharge treatment process works.

Defining the Process

As explained above, corona treatment changes the substrate material's surface molecules to increase its surface tension, thus its ability to hold an ink or coating effectively and reliably. When air near the material surface is corona treated, it breaks down into ozone, which reacts with the material, roughening its surface so that it can better hold onto the ink or the coating being applied. Surface tension is measured in dynes per centimeter, referred to as the surface's *dyne level*. In most cases, once the dyne level is about 10 dynes/cm higher than that of the liquid being applied, the result is better *wet out* and *adhesion*.

But what about all the ozone being created in this process? Various methods have been employed to trap or collect ozone and treat it, but many ozone filtration and destruction systems have been plagued by a tendency to leak ozone into the atmosphere. Newer ozone destruction systems with greatly simplified designs that reduce the risk of leaks have been developed that efficiently and reliably collect ozone and treat it with a catalytic converter before blowing it out into the atmosphere. Exhausted air from these new systems contains less than 0.1 ppm of ozone, and the airflow and filter can be continuously monitored to ensure the system's efficiency.

Testing the Surface Tension

Different films, inks, and coatings present a wide range of surface adhesion incompatibilities to be addressed by corona discharge. Some materials require higher levels of adhesion sometimes well above the typical 38- to 44-dyne range found in most processes. At the same time, a high-dyne job might be immediately followed by one that requires surface tension well below 38 dynes, requiring not only a system flexible enough to accommodate such dramatic changes, but also a way to measure dyne levels as accurately (and quickly) as possible.

There are many different ways to measure surface tension. A simple and popular, although somewhat subjective, method is to apply drops of a solution made from varying proportions of two chemicals. The solution can be prepared with various levels of the two chemicals to give it a surface tension level anywhere from 30 to 70 dynes per centimeter. Testing stations generally have a selection of pre-mixed, labeled solutions on hand.

The test involves swabbing or brushing the material with the solution. If the test solution wets the surface for two seconds before breaking into droplets, that means the material's dyne level is the same as the solution's. If the solution continues to wet the surface for longer than two seconds without breaking up, the material's dyne level is higher than the test solution's. In this case, higher-level solutions are used to test the material's surface tension until the level is determined. On the other hand, if the solution breaks into droplets in less than two seconds, its dyne level is lower than the solution's, and lower-level solutions are used to find the material's dyne level. Optimum results are obtained when the testing is done by starting at lower surface tension solutions and working up to higher-level mixtures until the proper one is found.

This test is, necessarily, only an approximate one, since there is no reliable way of measuring just when the solution breaks into droplets. Human error in timing the solution's breakup, or in the initial application of the solution, can affect the results. In addition, the same solution may act differently on different materials. Thus, a test that measures two different materials at the same dyne level does not ensure that the surface tension level of the two materials is really the same. The relative simplicity of this procedure, however, has made it the most popular method of surface tension level testing, especially for materials that are printing satisfactorily. Therefore, a benchmark reading can be made for those materials and used for subsequent treatments of the same materials to be processed with the same inks or coatings.

Another way to test dyne level is to use a test pen marker. Originally designed for solvent-based applications, the test pen method is very useful for checking overall consistency of treated materials, or for spot-checking pre-treated films. The pen is used to mark the material, and the tester observes the ink as it dries. At higher dyne levels, the ink dries darker, whereas on untreated film the ink breaks into tiny, almost invisible droplets as it dries.

A third method of dyne level testing involves measuring the angle between a droplet of water and the surface of the subject material. A higher dyne level on the material causes the water droplet to wet the surface more readily, creating a larger angle between the side of the droplet and the material surface, which can be accurately measured with an optical comparator or similar device.

Corona Treater Components

A corona treater system includes a power supply, a high-voltage transformer, and the treater station through which the material to be treated passes. The station itself typically consists of an electrode, an electrical insulator (dielectric), and a return path (ground). The treating station can be configured in any of a number of ways to accommodate different materials. An optional component is an ozone destruct system, also known as the OZD.

The power supply has a very simple function: it is there to raise the frequency and voltage of the incoming electricity. Power supplies need to be monitored and controlled, since the proper energy level being delivered to the web is important to the resulting corona discharge and material surface energy level. Generally speaking, the higher the kHz rating of the power supply, the lower the voltage of the corona being discharged; a high-frequency/low-voltage combination is ideal, as a lower-voltage corona is less damaging to the insulators, dielectrics, and treated substrate. Not all high-frequency power supplies operate at lower voltages, however, so before purchasing a power supply, work closely with your supplier to be sure you are getting the output you need for the materials you are treating.

A new development for power supplies is the Power Density Control. This control lets operators input web width and power density requirements for a particular job. A sensor automatically reads the line speed, and the system adjusts itself to the appropriate power supply for the output needed to deliver the proper corona treatment to the material.

Corona Treatment Configurations

The corona treating process can be applied to rolls of material of various widths and types. In addition, it can be used for treating finished parts, such as plastic bottles and caps, medication containers, syringe barrels, plastic surgical instruments, and so on.

For treating rolled materials, there are four basic corona treatment system configurations. These are defined essentially by the dielectric's location and the web material: conventional, bare-roll, double-dielectric, and convertible.

Conventional corona systems pass the web over a roll covered with an insulating material, such as a silicone rubber sleeve or ceramic coating. Between the web and the roll, usually with a 0.06-inch to 0.10-inch gap on either side, the electrode emits a high-voltage corona discharge into the air in the gap, ionizing the ambient oxygen and raising the material's surface tension. Although the conventional configuration is useful for many traditional nonconductive materials, it is not as effective for materials with foil or metallized components.

Bare-roll systems position the dielectric right on the electrode (because the roll in this configuration is typically made from anodized or bare aluminum, it has become known as "bare-roll"). The corona in this configuration forms in the air gap between the dielectric covering on the electrode and the material being processed. Bare-roll treatment is useful for both conductive and nonconductive materials, but can be less efficient treating nonconductives than the conventional configuration.

For more effective treatment of nonconductive materials, the *double-dielectric* configuration is more appropriate. "Double dielectric" means that the dielectric covering is located on both the electrode and the roll. This configuration has become much more popular in recent years, as it is very efficient for processing new types of specialized substrate materials that have been increasingly in demand.

Since it is generally hard to predict what kind of job a customer might come in with, presses need to be able to accommodate easily a wide variety of materials. This changeover must be quick and easy to accomplish since many of today's jobs can be very short and excessive downtime between jobs is extremely costly.

Thus, a fourth type of corona treating station has been developed the *convertible* configuration. A convertible station can be quickly and easily changed back and forth from conventional to bare-roll or double dielectric simply by flipping a selector switch. A variation of the convertible station, the *double-side convertible* allows the treatment of both sides of the substrate material in a single pass.

Costing Out the Treatment Process

As the packaging marketplace becomes ever more competitive, the pressures on film producers and converters to control costs at all levels continue to escalate. In addition, customers today are demanding higher and more consistent quality in package products, which can tend to add to the overall production costs. Thus, the challenge for packagers and converters: adapt to new materials, provide higher quality product, deliver it faster, and bring costs down.

While it’s easy to compare the initial acquisition prices of various treatment systems when considering which to add to your production line, one area of cost control that is frequently overlooked or underappreciated is the ongoing cost of operation. After all, what is the advantage of purchasing the system with the 20% lower price tag if it costs 40% more to operate every day?

Purchase prices might range from as low as $5,000 for a basic system, to nearly 100 times that for a state-of-the-art system with computer interface and remote monitoring and control. The actual operating costs of a treatment system depend on a number of factors, among them the system’s overall efficiency, its size, and local electricity rates. Other factors that affect the system price are line speed, web width, and desired treatment levels. Another part of the cost consideration is to be aware of how long it will take for the system to pay for itself, or to provide a return on the initial investment. In addition, operating costs of a system built 10 or more years ago will be higher than those for newer, more efficient systems. It’s entirely possible that replacing an old, inefficient treatment system with a newer model could pay for itself within just a few years.

Given the rapid developments in technology, processes, and materials, a system that is quickly outdated can become a huge drain on a company’s bottom line. The key to cost-effectiveness is to work with a supplier who is keeping abreast of these changes and designing their treatment systems in such a way that they can be easily and quickly customized or upgraded to meet new treatment and production challenges as they arise.

Determining the true cost of your corona treatment is more than simple dollars-and-cents accounting of purchase costs. You need to find a supplier who can sit down with you and understand both your immediate and your future needs.