Corona Treatment 101

Understanding the basics from a narrow web perspective

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Within the last few years the narrow-web processor has been faced with many new challenges. Among them is the more frequent need to be able to apply both water-based and UV-curable inks and coatings to substrates. This, combined with the increasing demand for flexible substrates, has brought new problems for the converter to solve in order to be competitive as well as profitable. Plastic substrates cannot be handled in the same manner as the more traditional materials were, because inks and coatings will not wet out or adhere to the surface unless some form of surface preparation is used first. These include primer-type coatings, chemical etching, flame treating, and corona discharge surface treatment. Although it used to be possible to produce a satisfactory product when the ideal combination of plastic substrate and solvent-based ink was used, this is definitely not the case with water-based or UV-curable inks. One solution — corona discharge surface treating — has been in use for decades by wide-web processors and converters. Today it is rare to find an extruder, laminator, or wide-web printer that does not employ one or more corona treaters in-line. There are important differences between a typical wide-web corona treating system and its narrow-web counterpart. It might be helpful first to understand how the process works and what equipment is required. Corona discharge surface treatment effects a change in the surface molecules of the material being processed such that the surface energy level (surface tension) is increased. The surface tension of a material is commonly referred to as its dyne level, since the common unit of measure for surface tension is dynes/cm. Once the dyne level of the surface is about 10 dynes/cm higher than that of the liquid being applied, good wet out and adhesion normally result. Although this is a good rule of thumb for most applications, there are applications in which the dyne level does not directly correlate either to wet out or adhesion, and these cases must be handled differently.

Voltage phenomenon

Corona discharge is an electrical phenomenon which occurs when air is exposed to a voltage potential high enough to cause ionization, thereby changing it from an electrical insulator to a conductor of electricity. The equipment used to accomplish this consists of a power supply, a high voltage transformer, and the treating station itself (Figure 1) which can be configured in various ways depending on the material being processed. There are essentially three types of treating configurations and they all consist of the same parts: an electrode, an electrical insulator or dielectric, and a return path or ground. The difference between the various configurations lies simply in where the dielectric is located. In a "conventional" configuration (Figure 2) the web passes over a roll which is covered with insulating material such as a silicone rubber sleeve. A metal "electrode" is suspended above the roll such that an air gap of .06"-.10" exists between the two. High voltage is impressed across this air gap causing it to ionize, forming a corona discharge directly between the bare electrode and the material being treated. While this configuration is the most efficient, it can process only nonconductive materials such as those that do not contain any foil or metallized components. A "bare-roll" configuration (Figure 3) places the

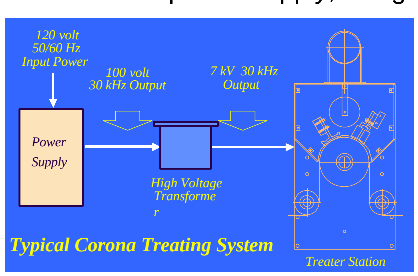

Figure 1

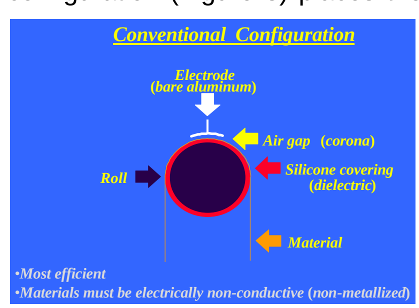

Figure 2

dielectric on the electrode. Since the roll is typically bare or anodized aluminum, the name "bare-roll" was adopted. In this case the corona is formed in the air gap between the dielectric covering on the electrode and the material being processed. While this configuration has the advantage of being able to process both conductive and non-conductive materials, it can be much less efficient at treating

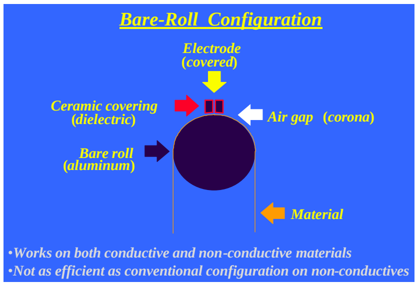

Figure 3

nonconductive materials than a conventional configuration. The third type of configuration consists of a system that processes non-conductive materials, but has a dielectric covering on both the electrode and the roll. This "double dielectric" system can have significant efficiency advantages when processing very specialized substrates, and its use is becoming more common. Although the typical wide-web treating system tends to be material specific, exactly the

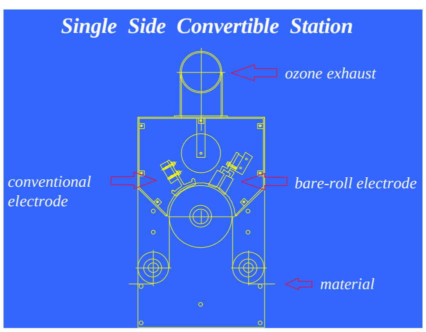

Figure 4

opposite is true for most narrow-web processors. They must have a treating system with the ability to run a wide variety of materials because they cannot predict in advance what their customers may want them to run in the future. For this reason it can help to have a system that features a "convertible" station configuration (Figure 4), which can be changed to conventional, bare-roll, or double-dielectric by simply flipping a selector switch. Since it is sometimes necessary to apply inks or coatings to both sides of the substrate, a station which can treat both sides of the material in a single pass may be desirable (Figure 5). Corona treating in-line is probably the most economical way to virtually guarantee consistently good product. Although purchasing pre-treated materials can also be an option, these materials are not to be trusted blindly due to variables which can degrade their dyne level during shipment, storage, and processing. That is why many narrow-web processors ensure excellent product quality by purchasing pre-treated materials and then "bump treating" them in-line in the printing press.

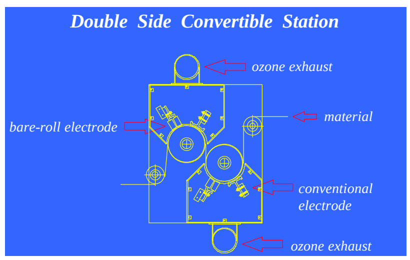

Figure 5

Costs

Initial purchase cost of a narrow-web treating system will typically range from $5,000 for a very basic system, to over $12,000 and higher for amore sophisticated system with computer interface or remote monitoring and control. The average system, however, probably ends up in the neighbor-hood of $8,000 to $10,000. Operating costs depend on system efficiency, size, and local electrical utility costs. They can run from as low as $0.05 per hour on up, but the typical narrow-web system will probably average around $0.12 per hour to operate. Materials respond to corona treating in ways that depend on their makeup. Generally, if web width and speed are held constant, dyne level increases in a non-linear fashion as power in the corona is increased. If we take into account the total treated width and speed, as well as the power developed in the corona, we arrive at a relationship referred to as "power density." Figure 6 indicates the

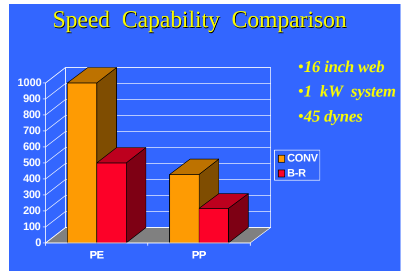

Figure 6

maximum speeds at which the example materials can be run with both bare-roll and conventional configurations. Assume that your press has a speed capability of 300 feet per minute and you must be able to run both of these example materials. As can be seen from the chart, your maximum speed would be limited to just over 200 feet per minute when running the polypropylene material on a bare-roll configuration. The conventional configuration, however, can exceed the maximum press speed of 300 feet per minute and therefore, would not limit production rates. If, in this example, you also needed to have the ability to run conductive materials, a convertible design would be necessary in order to avoid lowering production speeds on some materials. Both the material and treating configuration can affect how much power is required to achieve a given surface tension level. In fact, there are other variables as well which must be taken into consideration when designing a proper corona treating system. However, once the variables have been taken into consideration and the proper treating configuration has been selected, the relationship of power density to treatment level can be relied upon to provide consistent treating results. In fact, the corona treating system can be automatically adjusted through the use of a power density control system which will compensate for changes in material, width, and speed (Figure 7). These systems apply the power density formula to arrive at the power requirement for

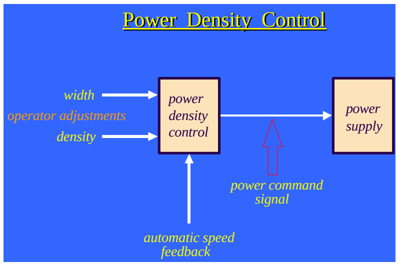

Figure 7

the process parameters currently being used, and automatically adjust the power supply to this level. A properly designed power density control will then adjust the power supply automatically in real time as changes in speed occur, thereby maintaining a constant dyne level on the material being processed.

Dyne testing

There are several ways to test the dyne level of a material before and after corona treatment. One popular method involves using solutions made from a mixture of two chemicals which, when combined in the correct proportions, result in a liquid with a surface tension level between 30 and 70 dynes/cm.

The test consists of applying a small amount of one of the solutions to the surface being tested using a cotton swab or brush. The surface is said to beat the dyne level of the test solution if it wets the surface for just two seconds before breaking into droplets. If the solution wets the surface for a longer period of time, the dyne level of the surface is higher than that of the solution being used and a higher level solution is then tested. The same holds true in reverse if the solution wets the surface for less than two seconds. This test is subjective because there is not always a clear definition of when the solution breaks into droplets. Moreover, the solutions do not react exactly the same way from one material to the next, and although the same dyne/cm indication might be observed on two different materials, this would not necessarily guarantee that the two materials were actually at the same surface tension level. In spite of these drawbacks, however, it remains one of the easiest methods for obtaining a numeric dyne level, and it can always be used as a benchmark once satisfactory printing or adhesion results are obtained.

Using the pen

Another method in common use is the 38 dyne/cm test pen marker. Although this device was originally designed as a go/no-go test indicator for solvent-based applications, it also happens to be one of the best indicators to use when looking for back side treatment, or treatment consistency in general. It is also useful when spot checking the level of incoming pre-treated film. This test consists of marking the test material with the pen and observing the characteristics of the drying ink. In this case the higher the dyne level the darker the ink appears as it dries, and on untreated film the ink breaks into tiny droplets which are almost invisible. It is also possible to measure the angle formed between a calibrated volume water droplet and the surface of the material being tested using an optical comparator, or similar device. Since the water droplet will more readily wet the surface as the dyne level is increased, the angle formed between the side of the drop and the surface will be greater with higher dyne levels.

Quality insurance

In summary, corona discharge surface treatment is an effective means of attaining the surface energy levels required for proper wet-out and adhesion of both water-based and UV-curable inks and coatings on virtually any substrate. When used in-line with the printing or coating process, it can be a very effective insurance against running bad product due to pre-treated materials which may have degraded to marginal levels. In addition, since the narrow-web processor will want the ability to address any and all market opportunities that may present themselves in the future, they will need the ability to run virtually any material without limiting production speeds. For this reason it is vitally important to specify a system which provides the greatest versatility and efficiency, so that the corona treating system does not become the limiting factor in press capability.

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