Corona Treater Station Design & Construction: Meeting the Converting Challenge

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Abstract

Treater station construction has undergone significant modification to accommodate rapid change in converting applications: lighter webs, higher line speed operation and advanced substrates(e.g., co-extruded, metallized and very thin substrates). This range of developments has introduced the requirement for nips at the treater roll, using the treater roll as a "pull roll" and modifying the treater station design to reduce wrinkling and "backside" treatment. Several different techniques were tried, but one, dual dielectric/coated roll technology has become by far the primary method used to overcome these problems. Various technologies are discussed and the current state-of-the-art in equipment, control parameters and applications are explained.

Station Design & Application Development

Prior to the early 1980s, treater station design for converting applications had remained essentially unchanged since corona treating was first applied to blown film lines. The station was enclosed, the roll was covered with a dielectric and the electrode was a metal rod in some form. Differences between stations boiled down to choice of three or four dielectric roll coverings and some relatively minor variations in metal electrodes. This was and is the basic, conventional Covered-Roll Station.

Metal Electrode Variations

The basic metal electrode was simply a straight metal bar (Figure 1). From the early sixties, when converters would often build their own stations, the bar electrode with simple variations such as an "L-iron" or "T-Shaped" iron or aluminum stock was the standard. In the mid to late sixties companies began to build corona treating systems for commercial sale and provide some measure of electrical and mechanical sophistication to the design. Specially designed electrodes were developed such as "shoe" electrodes, electrodes with patterned treatment surfaces, electrodes whose treatment surface was contoured to the treater roll circumference (Figure 2), and segmented electrodes (Figure 3) that allowed deckling of the electrode to vary the treat width or provide stripe treatment. Treater stations of these types are still manufactured and sold today. Many are still the basic, conventional Covered-Roll station with an enclosure built around the treating mechanism - the dielectric covered roll and metal electrode - and where the ozone exhaust intake is located at the perimeter of the station enclosure.

Recent Station & Electrode Advancements

In the early eighties, a station was developed that revolutionized the structure of both the electrode and the station. The first element of this revolutionary design was the movement of the dielectric covering from the treater roll to the treater electrode (Figure 4). This change allowed the use of ceramic as the dielectric medium since at that time covering a roll with ceramic was not technically feasible. It allowed the station to be of an "open" design and still provide operators with safety from electrical shock. And, it allowed the station to treat both conductive and non-conductive substrates. These benefits were well publicized and recognized at the time. Less recognized was the simultaneous development of an electrode assembly (Figure 5) that moved the location of the ozone exhaust from the perimeter of an enclosed station to the end of the electrode assembly. As the Bare-Roll provided the electrical freedom to eliminate the station enclosure, this change provided the mechanical freedom to eliminate the station enclosure and enabled the electrode assembly to rotate to allow the passage of web splices and knots. The enclosure was no longer required to capture and contain the ozone for removal. Instead the ozone was captured and removed immediately at the point of production in the air gap. This change was not given its proper recognition at the time, yet it provided significant benefits since it greatly reduced the opportunity for ozone to seep into the work area and, ultimately, permitted the construction of Covered-Roll stations in an Open design. Initially, these design advancements, were only used in the now well known and accepted Bare-Roll station.

The Bare-Roll Station found immediate application on converting lines (printing, coating and laminating in particular) because more and more converting applications were moving to water-based inks, coatings and adhesives. Where once the film extruder could provide treated film that was adequate for solvent-based converting, now the higher surface energy requirements of water-based (and later radiation-cured) converting necessitated in-line treatment on top of the treatment provided by the film extruder.

The Bare-Roll Station was ideal for converting applications because it offered:

1. The ability to treat both non-conductive and conductive webs.

2. No roll covering to fail which was a source of frequent problems with Covered-Roll stations.

3. Edge-to-edge treatment which the Covered-Roll could not do at that time.

4. Consistent treatment across the web, which is important as long as stripe treatment, was not required.
5. A higher level of operator safety from electrical shock while providing easier threading because of the open design.

6. Ozone removal and electrode cooling that maintained the electrode at a stable

temperature which eliminated warping and provided more consistent treatment while it provided an ozone safe work area.

7. A smaller diameter treater roll for a smaller more compact station.

8. A greater range of station mounting options to fit the line easier than most Covered-Roll stations could provide.

However, the Bare-Roll station was not without its limitations. They are:

1. The Bare-Roll station required slightly more power (kW) to treat difficult to treat substrates to a given dyne level.

2. The Bare-Roll station did not easily allow stripe or lane treatment which is frequently required on blown lines producing film for bags. This is especially true when the stripe treatment must be adjusted frequently to vary the treat and no-treat dimensions. Converting lines (printing or coating) seldom require stripe or lane treatment except for in-line printing on an extrusion line.

The Bare-Roll/Dual Dielectric Station is a recent development that overcomes the first limitation of the Bare-Roll station mentioned above (Figure 6). The dual dielectric station, which uses a special ceramic coating on the roll as well as the ceramic electrode, matches or betters the treating efficiency and effectiveness of any other system.

With one exception, the Bare-Roll/Dual Dielectric station provides all the benefits of the original Bare-Roll station. That exception is the fact that the special coating can, but seldom does, require repair or replacement. However, unlike the Covered-Roll station the dual dielectric station does not become unusable when the dielectric coating is pitted, cracked or pin-holed. Since the electrode is also ceramic covered, the station can continue to treat. The dual ceramic provides an additional benefit in that heat stress buildup during operation is shared and, therefore, neither electrode nor roll coating is subject to the same level of heat stress as that found in Covered-Roll stations during normal operation. This of course increases the long term, operational reliability of the coated roll.

The Bare-Roll/Dual Dielectric station provides an additional, highly significant benefit over the Bare-Roll and Covered-Roll stations. The dual dielectric station greatly reduces wrinkling even of ultra light substrates and reduces undesirable “back-side” treatment, i.e., treatment of the side opposite that being treated.

The Covered-Roll Station, with the arrival of ceramic covered rolls in the late eighties/early nineties, has seen a significant increase in long term operational reliability. These stations, which in the past could only claim a higher level of treating efficiency and the ability to stripe treat when compared to Bare-Roll stations, have recently undergone improvements that allow features once only available on the Bare-Roll station. For example, metal electrodes are now housed in assemblies that permit cooling air to pass over the electrode and remove ozone from the air gap - - the point at which it is generated. This structure and the extension of both the outer conductive shroud and the inner non-conductive shroud around the electrode assembly have allowed Covered-Roll, bare-metal electrodes to be housed in an open station while insuring a high level of personnel safety from shock (Figures 7 & 8).

This electrode assembly configuration also provides an additional operational benefit in that it can be built to easily rotate out of the way to allow web splices and knots to pass without damage to the electrode or assembly. After the splice or knot has passed, the electrode assembly is counter-weight balanced such that the assembly automatically rotates back into the treat position. Limit switches on each electrode assembly insure that the power supply can not be energized unless all electrode assemblies are in the treat position.

Driving & Nipping The Treater Roll

The requirement to drive or nip the treater roll is more often dictated by machine or film characteristics than by technical treatment demands. For example, treatment of ultra light weight film running under low web tension, has been seriously complicated by the tendency for these films to wrinkle under the corona discharge. The wrinkling not only causes a problem with the quality of the wound roll, but also produces backside treatment which can be detrimental to the final product.

Wrinkling and the resultant back-side treatment can be reduced by increasing the amount of wrap and tension of the film on the treater roll. For minor wrinkling problems this may be sufficient. For more serious wrinkling, the addition of a nip roll on the treater roll where the film enters the station can eliminate or mitigate the problem. The addition of a nip on the treater roll will require that the treater roll be driven, which will of course require a drive shaft on the roll. This may require a complete rebuild or replacement of the station.

If there is any question that wrinkling may be a problem on your application, it is best to plan ahead and provide space for the inclusion of a nip roll, if not having the nip roll installed immediately. Either of these steps would force the inclusion of a drive shaft on the treater roll. As an aside, most (that is over 50%) of corona treatment stations do not require the treater roll to be driven, therefore, most stations are not provided with a drive shaft. Films, even light films, will provide sufficient friction and tension to rotate the roll at line speed. Even if the roll does not rotate when the film is moving and treater power is off, the roll will rotate when treater power is applied. This phenomenon is referred to as electrical pinning and is used by companies manufacturing what are called electrical pinning bars. These devices are sometimes touted as electrical nips, but they are not nearly as effective as a mechanical nip roll. Their real benefits are that they are small and can be added easily after the machine has been installed, but they are not replacements for nip rolls.

Since the corona discharge provides electrical pinning of the film to the treater roll, one might ask: ‘Why doesn’t it prevent wrinkling?’ The answer is that even though the corona discharge will provide pinning power in many cases the force of that pinning is insufficient to overcome the static electrical forces that cause the film to wrinkle. That is why a mechanical nip roll can reduce the wrinkling problem and an electrical pinning bar cannot.

Driving the treater roll and, in some cases, adding a nip roll also can be required when working with films that are highly extensible. These films require highly uniform and tightly controlled tensions throughout the process. Using the film to drive the treater roll can cause an unbalanced tension from one side of the station to the other and, at times, this imbalance is sufficient to stretch the film thereby changing its gauge.

In some cases the machine builder will request that the treater station be constructed as a ‘pull-roll’. This requires that the treater roll be nipped and driven and provides the machine with a tension control point.

Sizing a Corona Treating System for Printing & Coating Applications

Treatment power is measured in Watt Density which takes into consideration not only power level but also the length of time the power is applied. (See Figure 9: Watt Density Formula.) If a given material is treated at a given watt density, its surface energy will be increased - - that is the basic goal of surface treatment. However, both the ultimate surface energy achieved and the amount of increase are dependent on the material’s starting surface energy. For example, applying a watt density of 1.2 to PET at 41 dynes may raise it to 46 dynes, but applying that same watt density of 1.2 to PET at 44 dynes may raise it to only 48 dynes. Although the final dyne level is higher in the second instance, the incremental increase is less because of the starting point dyne level. Further, the variation of barefoot (virgin) material response to corona treating is compounded by additive loading.

As you might expect, different materials react differently to corona treating. Some materials, such as most polyesters, accept treatment readily and will exhibit rapid increases in surface energy under relatively low watt density levels, say 0.9 to 1.2. Other materials, such as polyethylene, accept treatment less readily but will exhibit a significant increase in surface energy under moderate watt densities, say 2.0 to 2.5. Finally, some materials, such as polypropylene, are difficult to treat and may exhibit only moderate increases in surface energy under relatively high watt densities, say 3.0 to 3.5.

The materials and watt densities selected in the prior paragraph were chosen because they are somewhat typical of converting applications. However, treatment levels can vary considerably based on additive load and other film characteristics. (See Figure 10: Typical Converting Watt Density Requirements.)

Conclusion

Surface treatment in-line during converting processes is predominantly achieved using the corona process. This process provides several configurations of equipment to meet the widely varied technical and cost requirements of found in the converting industry. Despite increased line speeds, the move to ever lighter webs and lower web tensions and the introduction of co-extruded and metallized films, corona treating technology has advanced to offer both technical and cost effective solutions to surface treatment requirements for converting applications.

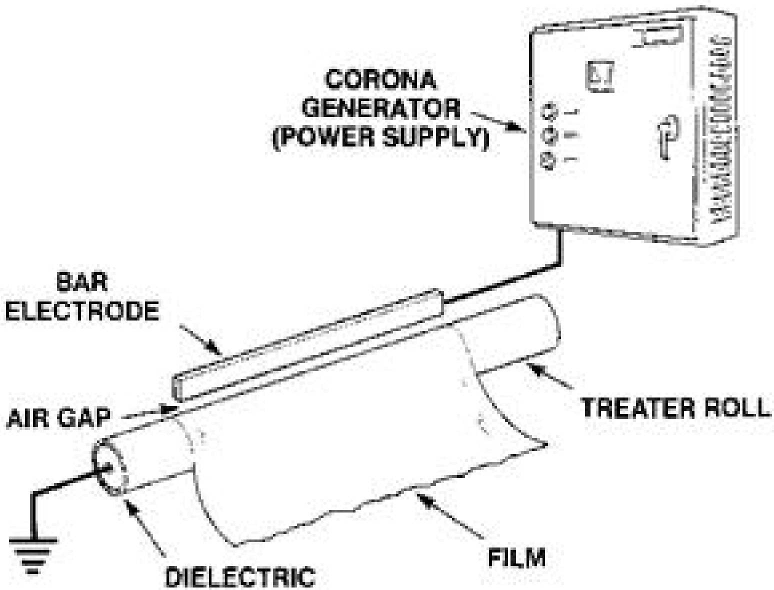

Figure 1: Bar Electrode

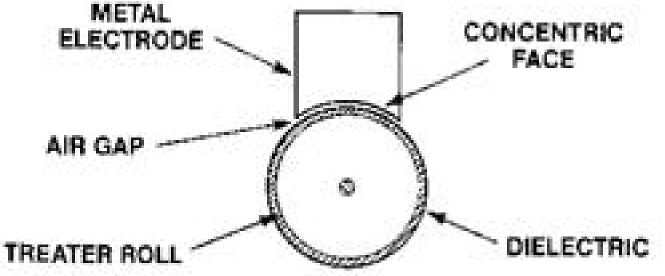

Figure 2: Concentric Cut Electrodes Side View

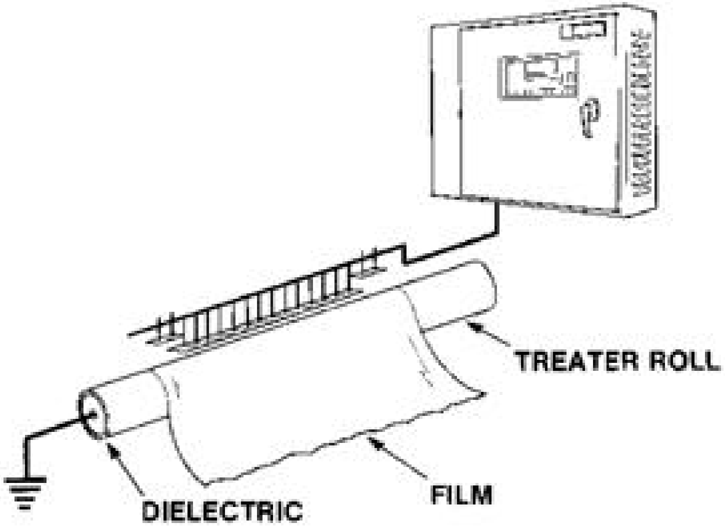

Figure 3: Segmented Metal Electrode

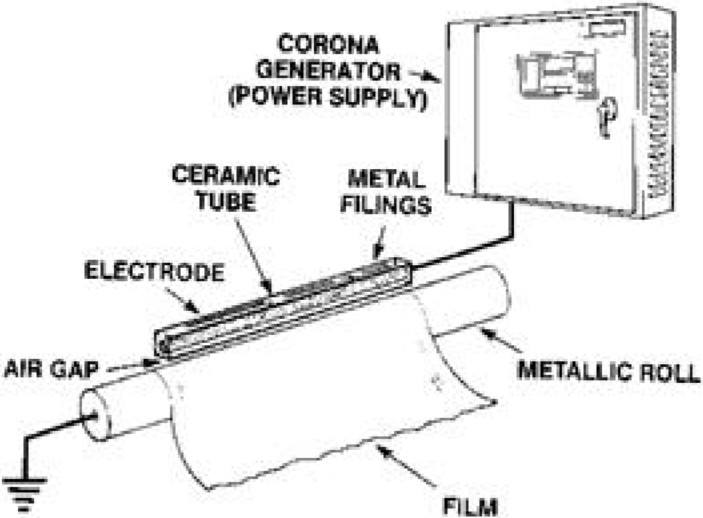

Figure 4: Ceramic Electrode/Bare Roll

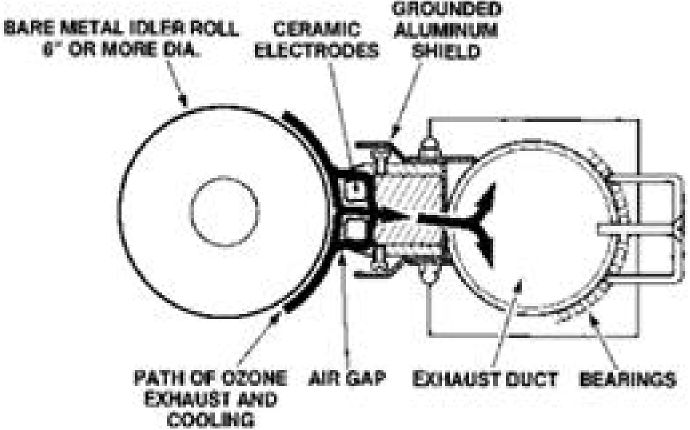

Figure 5: Ceramic Electrode Assembly Cross Section

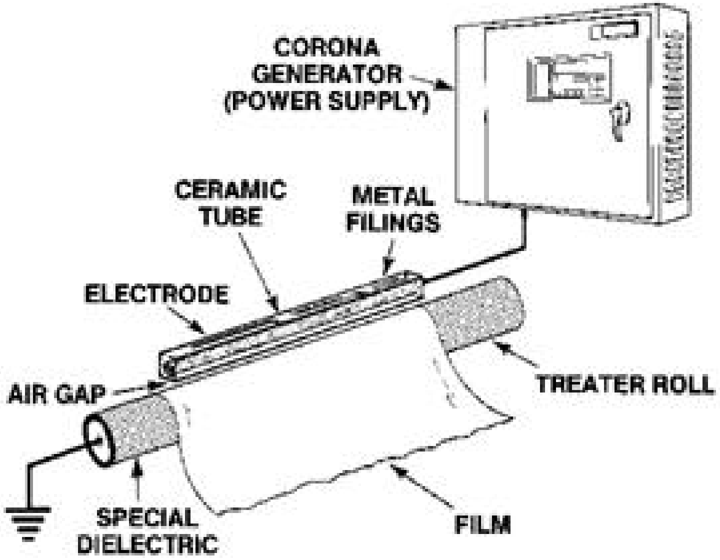

Figure 6: "H" System: Ceramic Electrode/Covered Roll

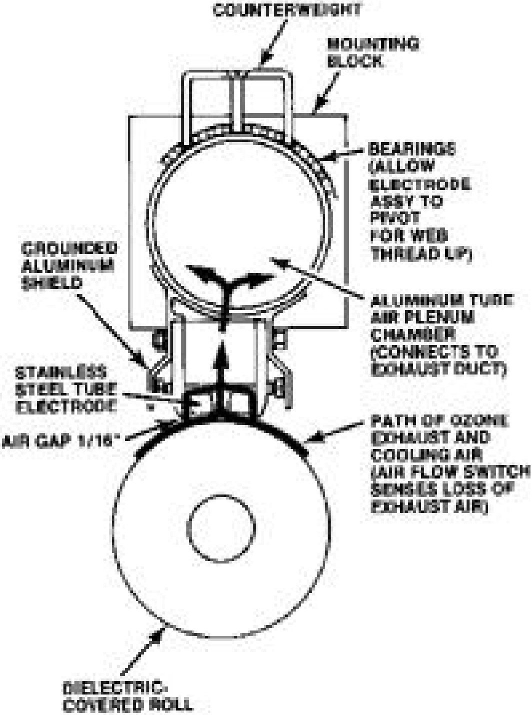

Figure 7: Stainless Steel Tube Electrodes

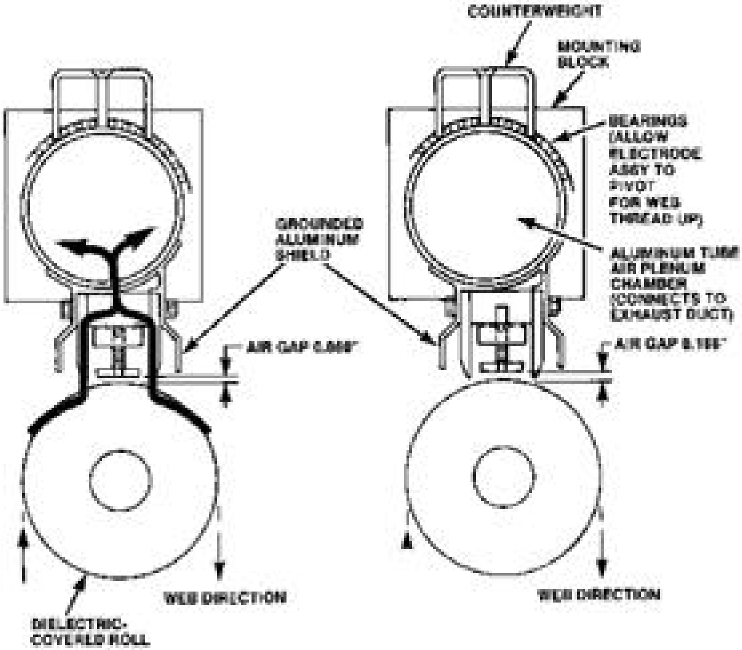

Figure 8: Stainless Steel Segmented Electrode

WD = PS(WW LS NST) *where*

WD	=	watt density, W/ft2/min
PS	=	power supply, W
WW	=	web width, ft
LS	=	line speed, ft/min
NST	=	number of sides treated

Figure 9: Watt Density Formula

Item Treated[a]	Application	Water-Based Watt Density[b]	UV/EB Watt Density[b]
Substrate	Flexo Printing		
Substrate	Gravure printing	2.0-4.0	2.5-4.5
Substrate	Specialty printing	2.5-4.0	--
Substrate	Coating	2+	2.5+
Substrate	Priming for	2.5	3+
Substrate	laminating	2.0	--
Substrate	Adhesives	2.0	2.5+
	Adhesives for	water wet	water wet
Coating	laminating	(70 dynes)	(70 dynes)
		2+	2.5+
	Laminating		

[a] Substrates (polyethylene, polypropylene, polyester, etc.) containing moderate additive load and corona treated at time of extrusion.

[a] Watt density is a relative number, not an absolute level.

Figure 10: Typical Converting Watt Density Requirements