CORONA TREATMENT

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Introduction:

There were many hurdles being faced in the past few years by the Plastic Conversion Industry one of which was inability of the water based and ultra based violate curable inks and coating, which adhere with the plastic substrates. This can now be achieved by plasma treatment or of using some form of surface preparation on to the plastic substrate with solvent based ink but this is subject to some form of surface preparation on to the plastic substrate. However this solution has some drawbacks such as short life of the viability etc. but when it comes to the water based or UV curable inks the above solution does not hold good. One perfect solution to this problem is using of Corona Treatment. In the Modern days it is rare to find an Extruder, Laminator or wide web printer that does not come with one or more corona treaters in line.

What is Corona Treatment: -

In corona treatment the film is passed over the roller through the air gap between the fixed electrode and the dielectric whereby the film is exposed to a very high voltage potential at a very high frequency, which causes ionization of air. The equipment used to achieve this comprises of a generator, which converts the available 230V / 415V, 50Hz power supply a high voltage transformer and the treating station itself. Now under the influence of the electric field, the ionized air molecules are made to move about. As the electric field increases, so does the speed and hence the kinetic energy of the

ionized air molecules. The random collision of these ions with other charged ions result in increase in the number of ions. Thus when sufficient electric field is developed, then the air gap can be said to have broken down into an ionized current carrying conductor. During this process the atmospheric oxygen is broken down into nascent oxygen and Ozone.

$$2O_2 \longrightarrow O + O3$$

The ozone is extracted out of the system where as the active nascent oxygen immediately oxidizes the film.

Components of a corona treatment system:

The corona treatment system mainly comprises of a power generation source and a treating station.

1) **Power generating source**: - This consists of a high frequency generator which uses the normally available 230V / 415V. 50Hz mains power supply to a very high volt frequency (about 40-50 KHz) and a high voltage output transformer.

2) **Treating station**:- The treating stations comprises of a high voltage electrode and a grounded roll. In order to produce a conducting atmosphere, either the electrode or the ground roll should have dielectric covering.

The treating station are broadly clarified in to two types:

1) Covered Roll 2) Bare Roll

1) **Covered Roll**: - In case of a covered roll, the ground roll is provided with a dielectric covering whereas the other high voltage electrode is a bare metal

. The advantages of using a covered roll treating station are:-

i) It is specifically designed for non-conducting substrates.

ii) Substrates with high slip are agents, which are difficulty to treat treated by using covered roll treatment stations.

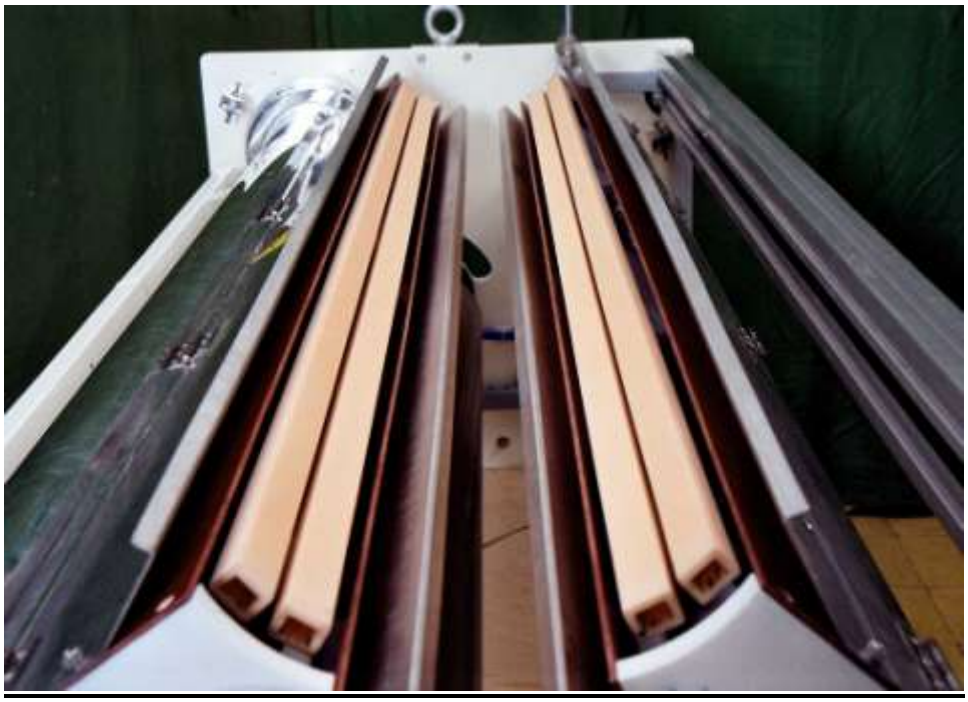
iii) Depending upon the customer specifications, variety of dielectric coverings ca is used.

Following are the disadvantages of using covered roll treating stations.

i) Metalzed substrates cannot be treated.

ii) Field repairability caused by the dielectric failures is very difficult.

2) **Bare Roll:** - Incase bare roll treating stations, the dielecting covering is provided on the high voltage electrode whereas the ground roll is just a bare metal.



Advantages of bare roll treating station are:

1. No need of Dielectric roller sleeve or a dielectric coating, which frequently need to be replaced or repaired in case of any puncture thereby increasing the downtime. In case of bare roll a bare stainless steel/aluminum roller is used as a treater roller.
2. Uniform corona treatment across the transverse width of the substrate.
3. This system can treat metallised (conductive) as well as non-metallised (non conductive) substrates.
4. Perforated webs can be easily treated in these systems.
5. The electrode width need not be adjusted as per the substrate width.
6. The High Dielectric constant and Low electrical resistance of the ceramic electrode help in achieving higher dyne levels of treatment. This is because the high dielectric strength helps in discharging high electrical power per square inch.

Disadvantage of bare roll treating stations are*:-*

1) High volume to air is required to cool the electrodes.
2) Certain substrates with high slip agents cannot be treated.
3) Efficiency is low as compared to covered roll electrode.
4) The cost of the bare roll treating station is high.

How to select a perfect corona treating system*:-*

1) Determine the type of basic material to be used onto which the corona tretment is to be done.
2) Specify whether the film is to be laminated / coated/ printed with which type of ink/covering also specify the initial dyne level of the film and whether the film is to be treated single side or double side.
3) Specify the maximum web speed (meters per minute) and maximum web width (mm).
4) Specify the maximum and the minimum thickness of the web.
5) Specify the basic electric supply and the variation.

How the system is sized.

Determination of power required*: -*

Referring to the graph below, the power faction (w/m^2/min) is calculated.

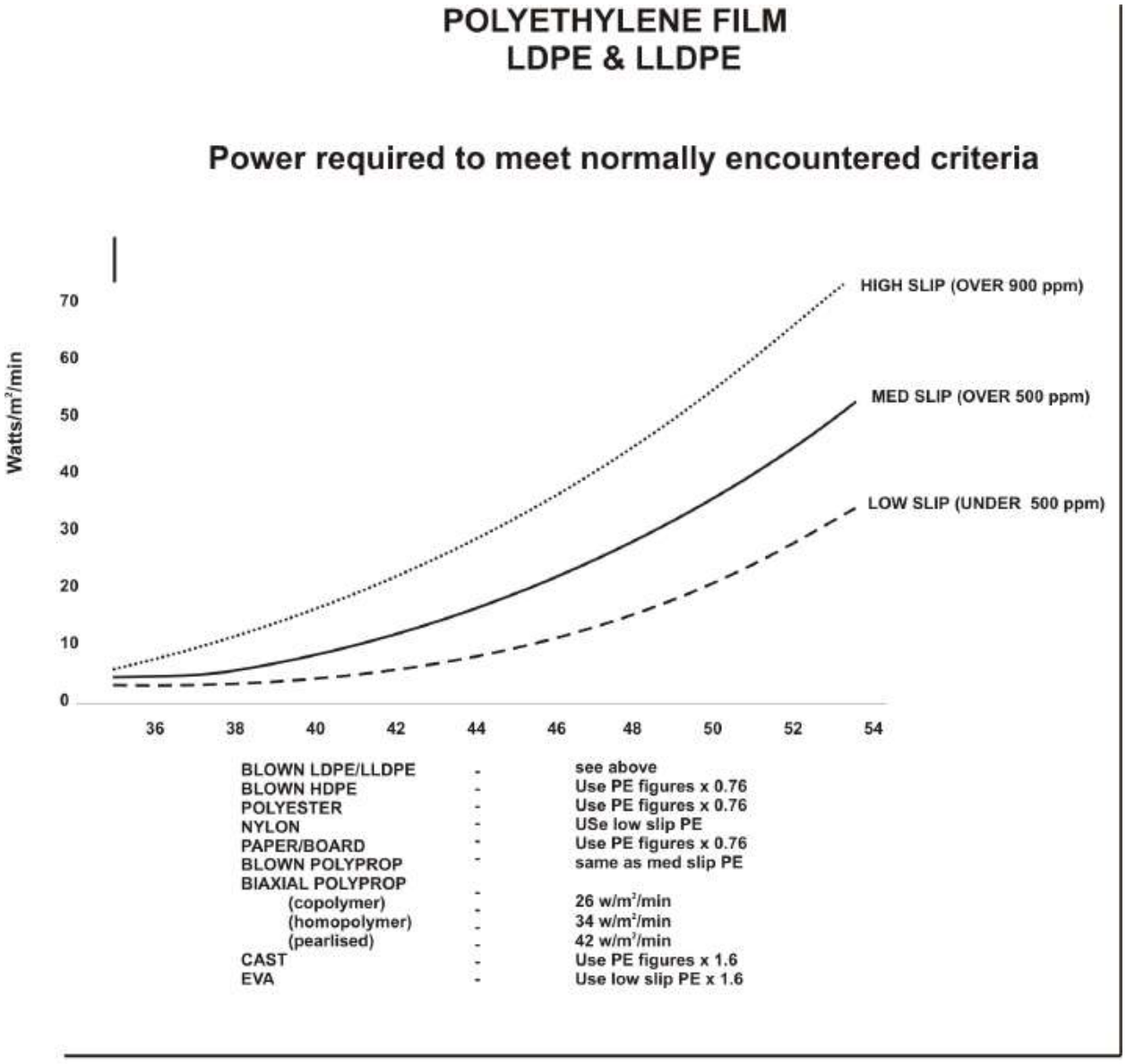


Figure 12

Generator power required (KW)

$$= \frac{\text{Line Speed (m/min) x Treat width (m) X Power factor (w/m}^2\text{/min) x no of sides}}{1000}$$

Using this generator power the specific electrical energy to be applied to the web width is calculated.

$$\text{Specify electrical energy} = \frac{\text{Max. generator power}}{\text{Max. Line speed x width x no of sides}} = \_\_\_\_\_ \text{w min/m}^2\text{k}$$

Using this specific electrical energy the discharge effectiveness can be correctly assessed.

$$\text{Power density} = \frac{\text{Max. generator Power}}{\text{Width x no of discharge lines x number of sides.}}$$

Finally taking into consideration the operating conditions the corona treater should be designed in such a way that the systems is of robust design and operator friendly.

HOW THE CORONA TREATMENT SYSTEM IS SIZED

TREATING ELEMENT	**SUGGESTIONS**
SUBSTRATE/MATERIAL	If the material is to be used for coating, printing, lamination etc .it is always advisable to use a pretreated film because it is very difficult to raise the treatment level of an untreated film in order to make it conducive for a good adhesion.
Width	Generally the stations are designed with wider roller face length and electrode length taking into consideration minor web shifting.
Thickness/Gauge	The films with lesser thickness generally require a driven treater roller arrangement. For treating the films with higher thickness the roller should be sturdy enough to bare the heavy tensions and deflections
Line speed	Line speed plays a very important parameter in designing the output power for the corona treatment. Generally for high line speeds the

	roller diameter should also be increased taking into consideration good wrap angle in order to Prevent the backside treatment (bump) treatment.
Additives	Depending upon the amount of additives the Output power of corona treater are decided. If the quantity of additives is more than 900ppm then higher power is required to attain the desired treatment level.
Application	Depending upon the type of application the corona treatment system is optimized as per the necessity of dyne levels.
Treat level	Please refer table No.1 for general Dyne level requirement.

Suggested Corona Treatment Levels								
	Flexo Printing			Screen Printing			Coating/Laminating	
Material	Solvent	Water	UV	Solvent	Water	UV	Solvent	Water
LDPE	36-40	39-44	40-50	39-44	42-48	46-60	38-45	42-50
HDPE	35-40	38-44	38-50	38-44	42-48	46-56	38-44	42-50
PET	40-46	44-52	42-54	42-48	48-60	44-62	42-48	42-60
PP	36-40	38-44	40-50	38-44	42-48	44-60	38-44	42-50
PVC	36-40	38-44	36-50	38-44	42-48	42-60	38-45	40-48

Table No.1

Problems caused due to Corona treatment

Blocking

The degree of oxidation of substrate is directly proportional to the level of treatment. The polar groups, which are formed during the corona treatment, have an attraction for the molecular layer present on the other side of the web. As a result of this when two sides that are in roll form come in contact with each other, self adhesion between the two sides take place. The adhesive force between the two sides is some times greater than the internal bond strength of the substrate as a result of which when the product is unrolled, delamination of the substrate takes place. Therefore it is always advisable to keep a optimum winding tension in the roll as greater the tension, more the blocking. Blocking increases towards the center of the roll.

Backside Treatment

When the air on the other side of the film which is to be untreated get ionized, it leads to the treatment of that side and the phenomenon is called as the backside treatment. This takes place because of the venturi effect. The film moving at a very high speed carries along with itself a cushion of air on both its sides. This trapped air can be removed from the untreated surface by providing higher tensions in the films and by increasing the diameter of the roller thereby increasing the wrap angle of the film with the roller. The other option is by providing a nip roller before the entry of the film into the treater roller.

Heat Seal ability

Excessive treatment onto the film may hamper the heat sealing property of some materials.

Pinholes

If the substrate contains traces of moisture or some conductivity, a heavy dosage of corona may get short through the spot thereby burning a small hole through the substrate.

Inherent surface tensions of substrates

Material	Surface tension (dynes/cm)	Material	Surface tension (dynes/cm)
Hydrocarbons		**Engineering Thermoplastics**	
PP, OPP,BOPP	29-31	PET	41-44
Polyethylene	30-31	Polycarbonate	46
Polystyrene PS	38	Polyamide	40
Low IONOMER	33	Polyaryl ether ketone	<36
Polystyrene		Polyacetal	<36
ABS	35-42	Polyphenylene oxide	
Polyamide	<36	PPO	47
Polymethyl Methacrylate		PBT	32
PMMA	<36	Polysulphone	41
Polyvinyl Acetate/		Polyethersulphone	50
Polyethylene copolymer		Polyarylsulphone	41
PVA/PE copolymer	33-44	Polyphenylene Sulphide	38
Epoxy	<36	Nylon	33-46
Polyester	41-44		

Rigid Polyvinyl Chloride	
PVC	39
Plascticized Polyvinylchloride	
PVC	33-38

Elastomers	
Silicone	24
Natural rubber	24
Styrene butadiene Rubber	48

What are Dielectrics in Corona Treatment?

In the modern times although corona treatment has been the integrated part of the Flexible packaging industry, the correct selection of dielectrics still remain the question to ponder upon.

Before we go into the technical analysis of the dielectrics, it is very important to understand the basic corona treatment. Primarily the corona treatment comprises of 4 basic parts

- Treatment station
- High frequency generator

- High voltage transformer
- Ozone extraction system

The function of the high frequency generator is to convert the mains power to a high frequency with the help of IGBT. The transformer steps up High frequency voltage to high voltage required to create the corona discharge which in turn is fed to the web in the treater area to cause the treatment.

Although the final treatment on to the substrate depends upon various factors. One of the important factor is the air gap that is maintained between the electrode and the substrate. It is not always the case that “more the power, more the treatment”. However because of the losses, not all of the power leaving the generator is converted into required corona. It is very important for the transformer to match the impedances of the treater assembly system with that of the generator. The mismatch of these impedances causes the generated power to reflect back to the generator in the form of heat. This in t turn affects the overall power factor of the system. Poor Power Factor means that the voltage and the current are getting out of phase. The high current drags down the output voltage thereby reducing the power in the air gap and also causing heat losses in the high tension cable.

The treater station configuration is often referred to as the **load** which is made up of the structure and the type of electrode, the air gap maintained, the type of substrate, and the dielectric sleeving used on the grounded roller. Hence it is very important to match the output power with the load in order to achieve the required efficient treatment. If there is any change in the load, it is necessary to tune the frequency accordingly. In

order to match the correct impedances it is very important to select the correct dielectric coverings.

Latest generation dielectrics

In the recent times there have been excellent developments in the field of dielectric materials with the intension of reducing the maintenance costs. In the bare roll concept of corona treatment, the traditional usage of the quartz tubes have been replaced by the high dielectric strength based ceramic electrodes. These electrodes are either packed with aluminum powder or metal rod which results in the corona discharge through the electrode.

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Before we go into the actual comparisons of the dielectric materials it is very important for us to understand the some of the definitions

Dielectric Strength: - It is the ability of the material to with stand the applied potential difference without causing the arcing across the insulator. It is very obvious that more the dielectric strength, less is the cross sectional area of the electrode. As the thickness of the electrode is reduced, less will be the power requires for the efficient corona treatment.

Dielectric Constant: - it is an indicative ability of an insulator to deliver the electrical charge. The capacitive impedance of the dielectric I directly related to the dielectric constant and the voltage gradient induced through the dielectric layer is inversely proportional to the dielectric constant..

Resistant to physical abuses: - The material should withstand the harsh environmental operating conditions of the corona treater. Splices. Knives cuts, web friction, moisture contamination, lump bangs etc can lead to the dielectric failure.

Ozone resistance: - The ozone which is a byproduct of the corona treatment is highly corrosive and affects most of the materials. The corrosion causes the structural damages of the materials which in turn reduces the dielectric strength and abrupt failure of the system. It is always advisable to use a material with excellent resistance to ozone.

Heat Dissipation: - The material that easily dissipates heat should be selected.

Porosity: - Porosity causes air entrapment and absorption of moisture which can cause tracking of the electrical discharge to the ground. A material with low porosity is recommended.

Field reparability: - When ever there is a premature arcing in the dielectric material, the treating system is non functional until it is replaced by a new one. It is always advisable to keep a spare dielectric roller or electrode in order to minimize the production losses.

Maximum service temperature: - High temperature often causes the burning of dielectric coverings. This can be reduced by optimizing the temperature in the system by force cooling in case of dielectric sleeved rolls and by creating a negative pressure in the ozone exhaust duct in case of dielectric electrodes.

Hardness: - Surface harness prevents abrasion

Costs: - Each application should be analyzed to determine the best material for that particular job. The cost is dependent on the selection of the treatment system.

COMPARISON OF DIELECTRICS					
	Dielectric constant	**Dielectric Strength(v/Mil)**	**Ozone resistance**	**Heat dissipation**	**Resistance to physical abuses**
Epoxy	3-4	450	Good	Fair	Excellent
Hypalon	5-6	400	Good	Fair	Poor
Silicone	4-5	450	Good	Good	poor
Ceramic	8-10	500	Excellent	Excellent	Excellent
	Field reparability	**Porosity**	**Maximum service temperature (C)**	**Hardness (shore A) Rockwell C**	**Costs**
Epoxy	Excellent	Good	87-120	70-80	Low
Hypalon	Fair	Excellent	65-150	60-90	Low
Silicone	Fair	Excellent	120	60-90	Medium
Ceramic	Poor	good	175	55	high

Hope this information should have cleared up some basic of the Dielectrics and its role in the corona treatment.