Determining the size of a corona treating system

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Web width and kilowatts alone do not tell us enough to determine the size of a treatment system. We need more information—such as the line speed, the type of material, and the number of electrodes needed to achieve the proper watt density.

A logical approach is essential in purchasing a corona treating system for extrusion, coextrusion, or extrusion coating or laminating. The most critical element in purchasing the system is its size. Here, we will examine parameters that affect the size. If the system is evaluated and sized properly, the costs will be reduced, the system will be effective, and the greatest value will be obtained.

Basic system rating

When selecting an electric motor, most purchasers understand that horsepower alone does not tell us enough to make a purchase. Data such as starting torque, operating speed, break-down torque, and intermittent operation also affect the specifications.

It is similar with corona treating systems. The starting point has been to look at the power supply kilowatts and the treater station width, because the width determines the maximum web width. These data, like horsepower by itself in selecting a motor, do not give us enough information to specify a corona treatment system.

The goal of any surface treatment system is to increase the product's surface tension measured in dynes per centimeter, which increases the wettability and adhesion characteristics of the surface. Corona treating systems achieve this by applying a specific level of power to the surface for a certain period of time. This power-time parameter is measured in watt density, which is defined as watts (power) per square foot per minute:

$$Wd = PS/(WW \times LS \times NST) \quad (1)$$

where

Wd = watt density, (W/ft^2)/min

PS = power supply, W

WW = web width, ft

LS = line speed, ft/min

NST = number of sides treated.

Although the watt density applied is directly proportional to the increase in surface tension, the relationship is not linear and is different for each type of material treated. In general, however, the surface tension increases with an increase in the applied watt density.

Watt density: conditional parameters

Watt density as a control function appears to be relatively easy to determine until we consider all of the parameters that affect watt density. These parameters can be broken down into two categories: (a) system parameters and (b) material and process parameters.

System parameters

System parameters are those governed by the corona system and machine design. The most obvious system parameters are power supply size (kW) and station size (web width). As Eq. 1 shows, the applied watt density is directly proportional to the power supply size and is inversely proportional to the station size. If you double the web width, then you must double the watt rating of the power supply if you want to maintain a constant watt density. This straightforward relationship is complicated by two factors: the line speed and the capacity of the electrode to accept a given level of applied power.

Each type of electrode, whether wire, metal bar, metal shoe, or ceramic covered, has an upper limit on the amount of power it can accept per unit length. If the power is increased beyond the electrodes' maximum rating, in an effort to achieve a given watt density for instance, then more electrodes must be added. Furthermore, an increase in the number of electrodes may lead to an increase in the diameter of the treater roll. Both of these factors may increase the physical size and the cost of the treater station.

Line speed is the second system parameter that complicates the calculation. The higher the line speed, the lower the maximum watt density that can be achieved. Line speed has a significant impact on the system size and cost.

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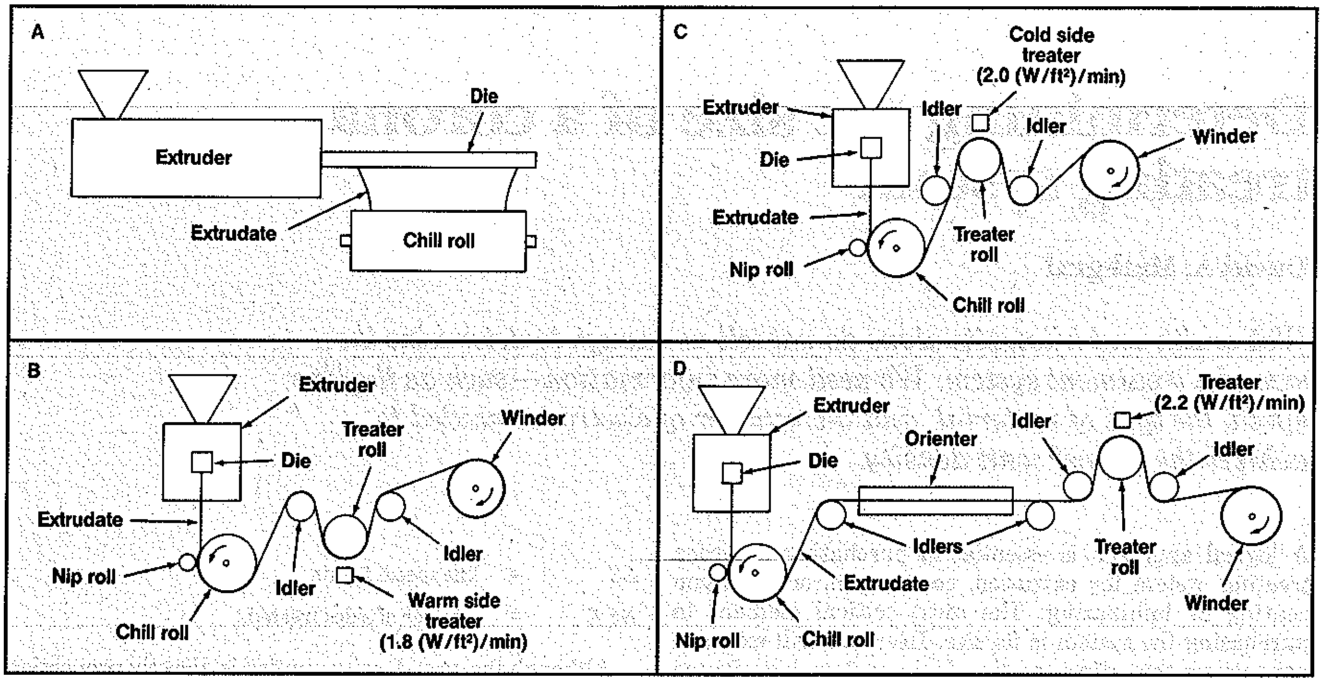
1. Cast film extrusion showing (A) the beginning of line (end view), (B) warm side treating, (C) cold side treating, and (D) biaxially oriented film treating



Material and process parameters

The most apparent of the parameters governed by the material and the process are the basic substrate material composition and the process being performed (such as extrusion, extrusion coating, or printing). As you analyze these factors in detail, their impact on the size of the corona treating system becomes increasingly complex.

Let's start with substrate material composition and assume that the materials are all "barefoot"—i.e., virgin material without any additives. The surface tensions of typical substrates used by the extrusion and converting industries are presented in **Table I** (*1*). As you can see, most of these materials are defined by a range of typical surface tensions. These ranges for surface tension values may be explained by several contributing factors, such as the method of manufacture (blown film vs. cast film), variations in die temperature at the time of extrusion, and the type and amount of impurities, which always exist in even the highest quality film.

If a material is treated at a specific watt density, its surface tension will be increased. However, both the final surface tension achieved and amount of increase depend on the starting surface tension. For example, applying a watt density of 1.2 (W/ft^2)/min to polyethylene terephthalate (PET) at 41 dynes may raise it to 46 dynes, but applying that same watt density to PET at 44 dynes may raise it to only 48 dynes. Although the final surface tension is higher in the second instance, the incremental increase in dynes is less because of the higher starting point. Furthermore, the variation of "barefoot" material response to corona treating is compounded by additive loading.

As mentioned, different materials or substrates react differently to corona treating. Some materials, such as some polyesters, accept treatment readily and will exhibit rapid increases in surface tension under relatively low watt densities of 0.9–1.2 (W/ft^2)/min. Other materials, like polyethylene, accept treatment less readily but will undergo an increase in surface tension under moderate watt densities of 2.0–2.5 (W/ft^2)/min. Finally, some materials, such as polypropylene, are difficult to treat and may have only moderate increases in surface tension under relatively high watt densities of 2.5–3.0 (W/ft^2)/min.

Variations in material response to corona treating are further compounded by differences in process parameters. Extrusion, extrusion coating, and extrusion laminating require different intensities of treatment to achieve acceptable product quality and production levels. However, blown film extrusion of a given resin will produce a substrate with a post-treatment response different from that produced through cast film extrusion. A further complication that increases watt density requirements is the combination of cast extrusion with tenter frame.

The differences in corona treating response between blown film and cast film extrusion are due to several elements:

- Molecular structure variations as a result of the extrusion process
- The temperature of the substrate at the time it enters the treating station
- The location of the treating station relative to the point of extrusion.

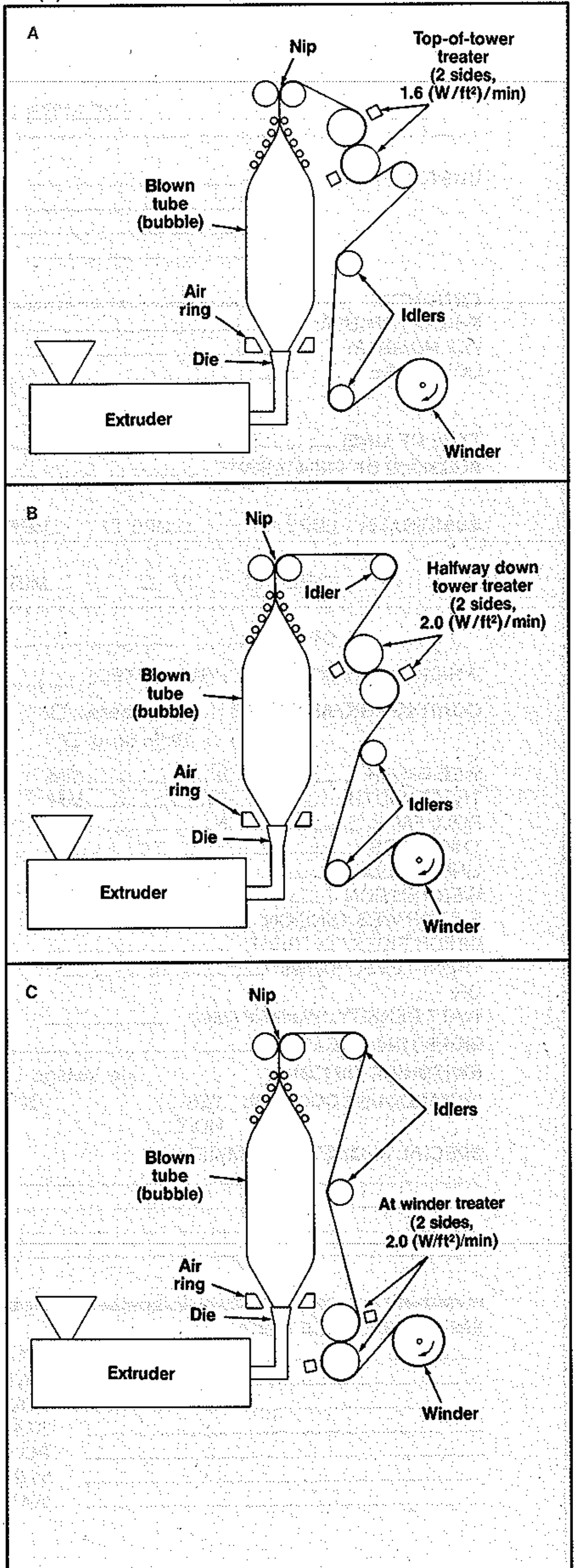
In the cast film application, the film is extruded and cast onto a chill roll. Then it may be biaxially stretched while being heated before being wound. Corona treating can occur immediately after the chill roll on either the warm or cold side of the film. On oriented or biaxially oriented film, the corona treater is placed after the orienter. Watt density values are shown in **Fig. 1A–D** for each instance.

1. Typical substrate surface tensions

Polymers	Surface tension, in dynes/cm
Hydrocarbons	
Polypropylene (PP, OPP, BOPP)	29-31
Polyethylene (PE)	30-31
Polystyrene (PES)	38
Polystyrene (low ionomer)	33
ABS	35-42
Polyamide	<36
Polymethyl methacrylate (PMMA)	<36
Polyvinyl acetate/ polyethylene copolymer (PVA/PE copolymer)	33-44
Epoxy	<36
Polyester	41-44
Rigid polyvinyl chloride (PVC)	39
Plasticized polyvinyl chloride (PVC)	33-38
Phenolic	. . .*
Fluorocarbons	
Chlortrifloroethylene (CTFE) (Aclar®)	. . .
Polytetrafluroethylene/polyethylene copolymer (PETFE)	20-24
Fluorinated ethylene propylene (FEP)	18-22
Polytetrafluoroethylene (PTFE) (Teflon®)	19-20
Polyvinylidene fluoride	25
Polyvinyl fluoride (Tedlar®)	28
Engineering thermoplastics	
PET	41-44
Polycarbonate (PC)	46
Polyimide	40
Polyaramid	. . .*
Polyaryl ether ketone	<36
Polyacetal	<36
Polyphenylene oxide (PPO)	47
PBT	32
Polysulfone	41
Polyethersulfone	50
Polyarylsulfone	41
Polyphenylene sulfide	38
Nylon	33-46
Elastomers	
Silicone	24
Natural rubber	24
Latex	. . .*
Polyurethane	. . .*
Styrene butadiene rubber	48
Fluoroelastomer	
Fluorocarbon copolymer elastomer	<36

*Data not available at this time.

2. Blown film extrusion showing treatment (A) at the nip, (B) halfway down, and (C) at the winder



3. Example data sheet for the corona treater

DATE: ______
SALESMAN: ______
PREPARER: ______

TREATER DATA SHEET

CUSTOMER: ______

EXISTING EQUIP: ______

CONTACT: ______
PHONE NUMBER: ( ) ______
FAX NUMBER: ( ) ______
COPIES TO: ______

QUOTE THE FOLLOWING:

POWER SUPPLY ONLY ☐ STATION ONLY ☐
COMPLETE SYSTEM ☐
WRITTEN QUOTE REQ. BY: ______
BID PROPOSAL CLOSING DATE: ______

TYPE OF LINE: ______
PURPOSE OF TREATMENT: ______

SUBSTRATE: LDPE ☐ LLDPE ☐ HDPE ☐ PET ☐ **FOIL:** CLASS A ☐ CLASS B ☐ CLASS C ☐
PAPER ☐ PP ☐ **METALIZED:** Transfer ☐ Vacuum ☐
OTHER: ______

WHICH SUBSTRATES ARE PRETREATED: ______

COATING/INK/ADHESIVE: Water-based ☐ Solvent-based ☐ Extrudate ☐
100% Solid ☐ Hot Melt ☐ UV ☐ EB ☐

WEB WIDTH: ______ IN ______ MM
TREAT WIDTH: ______ IN ______ MM
ROLL FACE: ______ IN ______ MM
THICKNESS: ______
LINE SPEED: ______ FPM ______ MPM
WEB TENSION: ______ PLI
E-STOP WEB TENSION: ______ PLI
WHICH SIDES TO TREAT: ______
TREAT LEVEL: (Dynes) ______
OR
WATT DENSITY: (Watts/ft²/Min) ______

ADDITIVES
SLIP ______ PPM
TiO_2 ______ PPM
ANTI-BLOCK ______ PPM
COLOR ______ PPM
ANTI-STAT ______ PPM
EVA ______ %
OTHER: ______ ______ PPM

MOUNTING LOCATION: ______
SWITCHING OPTION: Low Voltage ☐ High Voltage ☐ None ☐
HAZARDOUS LOCATION: YES ☐ NO ☐ QUOTE AS OPTION ☐ OR WITH SYSTEM ☐
SPECIAL REQUESTS/COMMENTS:

______

ENGINEERING USE ONLY:

FT²/MIN ______
WATT DENSITY ______
POWER SUPPLY ______
STATION ______
PLI (MAX) ______
W (MM) ______
WATTS/INCH ______

4. Example data sheet for the extrusion coater

DATE: ____________

EXTRUSION COATER DATA SHEET

MFG. REP: ____________

CUSTOMER: ____________ ____________ ____________ ____________

CONTACT: ____________
PHONE NUMBER: (   ) ____________
FAX NUMBER: (   ) ____________
COPIES TO: ____________

TYPE OF LINE: EXTRUSION LAMINATOR ______ COATING MACHINE ______ TANDEM EXTRUDER ______ MONO EXTRUDER ______

IF COATING AND LAMINATING IS IT: MONO ______ TANDEM ______ TRIPLE X ______

LINE SPECS: PRODUCTION SPEED ______ MAX. MECHANICAL SPEED ______ MAX. WEB WIDTH ______ MAX. TREAT WIDTH ______ MAX.

ROLL FACE ______
E-STOP PLI ______
WEB TENSION MAX. ______ PLI

MACHINE ROLL(S): Diameter ____________
MOUNTING LOCATION: HAZARDOUS ____________ NON-HAZARDOUS ____________

PRIMARY UNWIND-MATERIAL: LDPE ____ LLDPE ____ HDPE ____ METALLIZED POLY ____ FOIL ____ PAPER ____ PP ____ PET ____ BOARD STOCK ____ OTHER ____

WHICH MATERIALS ARE PRETREATED: ____________
____
MATERIAL THICKNESS ____________
WHICH SIDES TO TREAT: ____________
TREAT LEVEL: ____________

ADDITIVES:
SLIP ______ PPM
TiO_2 ______ PPM
ANTI-BLOCK ______ PPM
COLOR ______ PPM

SHAFT EXTENSION REQUIRED: YES ☐ NO ☐

AUXILIARY UNWIND POSITION – MATERIAL: LDPE ____ LLDPE ____ HDPE ____ METALLIZED POLY ____ BRAND STOCK ____ FOIL ____ PAPER ____ PP ____ PET ____ OTHER ____

WHICH MATERIALS ARE PRETREATED: ____________
____
MATERIAL THICKNESS ____________
WHICH SIDES TO TREAT: ____________
TREAT LEVEL: ____________

ADDITIVES:
SLIP ______ PPM
TiO_2 ______ PPM
ANTI-BLOCK ______ PPM
COLOR ______ PPM

SHAFT EXTENSION REQUIRED: YES ☐ NO ☐

POST-TREAT POSITION – MATERIAL: LDPE ____ LLDPE ____ HDPE ____ METALLIZED POLY ____ FOIL ____ PAPER ____ PP ____ PET ____ OTHER ____

COATING THICKNESS: ____________
MATERIAL THICKNESS: ____________
WHICH SIDES TO TREAT: ____________
TREAT LEVEL: ____________
MATT FINISH: ______ GLOSS FINISH ______

ADDITIVES:
SLIP ______ PPM
TiO_2 ______ PPM
ANTI-BLOCK ______ PPM
COLOR ______ PPM

SHAFT EXTENSION REQUIRED: YES ☐ NO ☐

(1) IS TREATER ENVIRONMENT VERY DIRTY? ____________ **(i.e. paperboard dust, near regrinder)**
(2) WILL TREATER ROLL BE USED AS A PULL ROLL? YES ☐ NO ☐
(3) ARE THERE OTHER TREATERS USED IN CONJUNCTION? (i.e. flame, corona, ozonator) YES ☐ NO ☐
OTHER COMMENTS:
____
____
____

ENGINEERING SPACE FOR SIZING: (use other side)

However, the exact watt density value is not as informative as the relative differences between values shown at each location.

The treatment of blown film shows similar differences based on the position of the treater station. **Figure 2A-C** demonstrates that the watt density required is lower when the treater station is located at the nip at the top of the tower than when it is located halfway down the tower or at the bottom of the tower just prior to the winder. The *Wd* required does not change between Figs. 2B and 2C because the film temperature between these points is essentially constant.

Other factors affecting watt density

So far, we have dealt with the major factors of treatment system design, application requirements, and basic material (web) composition. A number of other factors also cause an impact on treatment response and the ability of a web, film, or other substrate to sustain a treatment level. These other factors include retreatment, time, and additive loading.

Retreatment

Retreatment is the situation in which a previously treated web is treated again in-line just prior to the completion of a converting process. For example, a film that was treated at the time of extrusion may be treated again on a coating line just prior to the lay-down of a water-based coating. This retreatment process is not unusual when dealing with film containing some additive loading that is stored for a period of time between its extrusion and the coating process.

Retreatment is more common when water-based coatings are used, as opposed to solvent-based coatings, which wet-out and adhere more readily. For example, a film with a surface tension of 31 dynes as extruded may be treated to a level of 40 dynes on the extruder. After shipment and storage, the effect of time and additive loading may reduce the film's surface tension to 36 dynes or less. At this level, solvent-based coatings may well provide a high quality product without further treatment. However, a water-based coating may require that the film be retreated to raise its surface tension to 40 dynes or more. Our experience has been that retreating a previously treated film requires a lower watt density than treating a film that has not been pretreated.

Additive loading

Additive loading is the amount of additives in parts per million contained in the film. These additives have an impact on a film's ability to be treated and to retain the effect of corona treatment. With more additive loading, higher watt densities are needed to raise the film's surface tension. Additive loading will also reduce the film's ability to maintain the effects of corona treatment. This difficulty arises from the tendency for additives to bloom or migrate to the surface and mask the effect of corona treatment. It is commonly held that additives will more readily migrate to a film surface that has been treated.

Time

Treated surfaces will lose treatment over time (*2*). This is true for all methods of surface treatment and all films, even those with no additives. The amount of treatment loss is dependent on the type of film, the type of treatment, the intensity of treatment, and the amount of time.

One study done on an extrusion coating application demonstrated that between 1% and 7% of treatment was lost in the first 9 days after treatment. By 37 days after treatment, between 32% and 38% of the treatment had dissipated (*3*).

Conclusion

To determine the size of a corona treatment system for a particular application, a number of specific parameters must be considered. To ensure that this is done properly, treater suppliers have developed data sheets that systematically present all of the information that will affect the size of the treater system.

Figure 3 is an example of a data sheet for general treater applications, while **Fig. 4** is an example of a data sheet for extrusion coating. Each item affects the physical or electrical design of the system and, ultimately, the ability of the system to meet the requirements for performance and long-term reliability.□

Literature Cited

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Received for review Apr. 15, 1989.

Accepted May 9, 1989.

Presented at the 1989 Coextrusion Short Course.