Claudia Benelli, Director, Ferrarini & Benelli

Surface Treatment – Necessity or Luxury?

Generally, plastic films have inert and non-porous chemical surfaces, with low surface tensions, which make them non-receptive to the anchoring of substrates such as printing inks, adhesives and coating. Amongst different plastic films, polyethylene and polypropylene films have the lowest surface energy and therefore undergo corona treatment more often, in order to enhance their adhesion properties. However, corona-effect surface treatment is not limited to these two materials and can also be used to enhance adhesion properties of basically all plastic materials as well as some materials of other nature. Two non-plastic materials that undergo surface treatment more frequently are aluminium and paper.

All substrates, plastics films, paper and aluminium provide best surface adhesion when treated at the time of their manufacturing. Such application, which is called post-treatment, is used to intensify adhesion during other converting processes such as printing, lamination, etc.

FACTORS AND PARAMETERS. The ultimate goal of every surface treatment system is to increase product surface tension, measured in dyne/cm as well as to enhance wettability and surface adhesion properties. Corona treatment systems achieve such results by applying a given power, for a given time on the surface. This power parameter in time is measured in watt density, defined as Watt*minute/m^2.

Wd=PS(w)/WW(m)*LS(m/min)*NST

Wd= watt power density (watt/m^2/min)
PS(w)= supplied power (watt)
WW(m)= film width (m)
LS(m/min)= line speed (m/min)
NST= number of sides to be treated

CONDITIONAL PARAMETERS OF WATT DENSITY. There are two parameters that affect power density: system and process-material parameters.

SYSTEM PARAMETERS. Most obvious system parameters are measurement of supplied power (KW) and measurement of treatment station (film width). Applied power density is directly proportional to measure of supplied power in watt and inversely proportional to treatment station measure expressed in meters; this means that in order to maintain a given power density, if the film width doubles even the watt quantity of supplied power must be doubled. This direct relation is complicated by two factors: operative speed and electrode capacity to distribute a given level of applied power. Each type of electrode has a maximum power limit it can accept for length units. If a given power density KW exceeds the maximum limit of what an electrode can distribute, it will be necessary to add other electrodes. Increasing the number of electrodes could impose adoption of a discharge roller with larger diameter. Both factors lead to an increase in the size of the treatment station to be used and its cost.

Operative speed is another system parameter, which can complicate calculations for plant sizing. With a given plant, the higher the operative speed, the lower the maximum power density attainable. Thus, speed, which is inversely proportional to power density, has a relevant impact on sizing and cost of a corona treatment system.

PROCESS-MATERIAL PARAMETERS. Most apparent process-material parameters are substrates composition and type of process they undergo (extrusion, extrusion coating, printing, etc.).

Many materials are defined by a range of typical surface tensions. Different surface tension values of a given material could be explained by several factors, such as processing method (blown or cast film), die temperature variations during extrusion, type and quantity of impurities that are always present even in high-quality films. If dealing with a material having a given power density its surface tension will be increased. Yet final surface tension and increase amount depend on the material's initial surface tension.

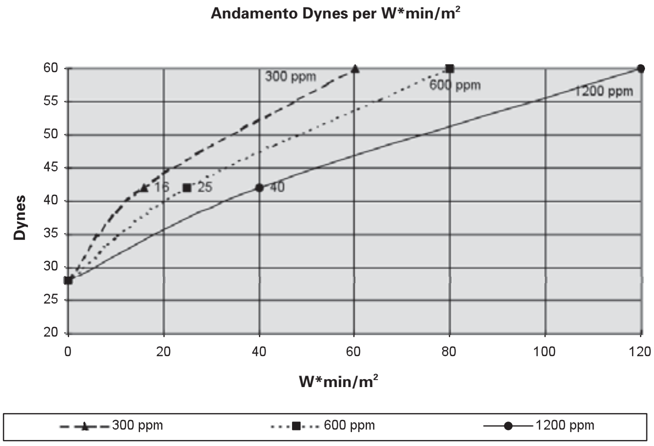
For example, by applying a given watt power density to a 41 dyne activated PET, it will be possible to reach 46 dyne, but applying that same power density to a 44 dyne activated PET, only 48 could be attained. Although in the latter case the final level is higher, the increase is inferior due to the initial level. Furthermore, the variation of barefoot material response to corona treatment is compounded by additive loading.

Not all materials or substrates react in the same way to corona treatment. Some materials, such as certain polyesters, can be treated without problems and show rapid surface tension increase using relatively low power intensity levels. For other materials, such as polyethylene, treatment poses more difficulties, however, significant increases in surface tension can be reached using medium-low levels of power intensity. Finally, some materials, such as polypropylene, are difficult to treat and may show only moderate surface tension increase using relatively high power intensity levels.

Reaction of a material to corona treatment is also affected by the different manufacturing process parameters. It is known that extrusion, extrusion coating, and lamination by extrusion processes require different treatment levels to reach acceptable product and production quality levels. Nevertheless, it is less known that the type of manufacturing affects reactions of a given substrate to corona treatment. These differences are due to the following elements:

1. Variation in molecular structure as result of the extrusion process.
2. Substrate temperature at the time it enters the corona treatment unit.
3. Location of the corona treatment unit relative to the point of extrusion.

ADDITIVE CHARGE. Additive charge, expressed in parts per million (ppm) contained in the film, remarkably influences a film's capacity for corona treatment and retains its effects in time. The first consequence of an elevated additive charge is that of requiring an increase in power density to enhance the film surface tension. Secondly, an elevated quantity of additive in the film reduces a material's capacity to maintain a corona treatment effect in time. This is caused by the additives' tendency to group together or migrate to the surface and mask the effect of corona treatment. It is commonly believed that additives will migrate more rapidly towards a film surface, which has been treated.



The diagram in Figure 1 shows that the possibility of treatment decreases with the increase of the lubricant percentage. The example shows that about 16 W*min/m^2 are necessary to treat a PE film with 300 ppm of lubricant at 42 dyne/cm. If the lubricant content were 600 ppm the amount of necessary corona effect would rise to 25 and if it were 1200 ppm it would increase to 40 W*min/m^2. For a material not containing lubricants, an amount of corona effect equivalent to about 7 W.min/m^2 is applied.
This means that for treatment of films containing lubricants, increased electric power must be applied compared to that necessary for treatment of lubricant-free materials. For the same result, electrodes with increased discharge surface are necessary, since an increased discharge electrode surface with equivalent film sliding speed causes increased film exposure time under corona discharge.

TREATMENT RENEWAL. Treatment renewal is that situation, in which a film that had previously undergone treatment is treat-

Fig. 2: Polimetal Corona Treatment

Fig. 3: Corona Generators

ed again in-line with the corona process before completion of the converting process. For instance, a film already treated for extrusion could be treated again in the laminating, coating or printing process.

Treatment renewal is more commonly used in the presence of water-based coatings or inks; on the contrary, solvent-based coatings or inks wet more easily and their adhesion is simpler. For example, a film with 31 dyne surface tension at extrusion can be treated to a level of 40 dyne in line with the extruder. After transport and stocking, the effect of time passing and additive charges, surface tension is reduced to, for example, 36 dyne or even less. At this level, solvent-based coatings or inks would already provide elevated product quality, without needing further treatment. However, a water-based coating or ink would require the film to be treated to increase its surface tension to 40 dyne or more. Experience proves that, with a given surface tension increase, re-treating pre-treated films requires less power intensity than treating a non pre-treated film. Moreover some non pre-treated materials do not increase their surface tension even if very elevated power densities are applied. This is due to their molecular structure and slipping barrier or additives, which migrate, to the film surface, reducing surface tension.

TIME. With time treated surfaces progressively lose the effect of the treatment. This is always true for all treatment methods and all films, even non-additivated ones. The amount of treatment loss depends on the type of film, treatment level, type of treatment, additive quantity and elapsed time.

Unfortunately some of the beneficial results obtained by the corona treatment degrade after treatment. Main reasons for this are:

1. It is thought that the main cause for this loss is that each subsequent rubbing of the treated surface on transmission rollers, reel, drum, etc., tends to «remove» treatment.
2. Contact between treated side and opposite side.
3. Content of slipping agents.

It should also be noted that once final processing, such as printing, coating or lamination is over, anchor enhancement obtained with corona treatment remains stable. In other words, ink will not come off after a period of time and the two substrates will not delaminate. Treatment «loss» occurs in the period of time between treatment and the consequent converting process. Yet an elevated initial treatment level is not a solution to the problem.

It must also be said that, if a material contains added components such as additives and slipping agents, treatment at the time of use is more efficient, if the material has already been treated at the time of extrusion. This case is called treatment reinstatement or renewal.

Ferrarini & Benelli Srl.,
I-26014 Romanengo (CR),
www.ferben.com