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CORONA TREATMENT AND ITS IMPORTANCE IN FLEXO PRINTING

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Abstract: *With the increasing importance of flexible packaging in recent years, the trend of packaging printing in the printing industry has increased. The most widely used printing systems in flexible packaging printing are flexo and rotogravure printing. Although rotogravure printing is as high quality and fast as flexo printing, it has made flexo printing more preferable because the printing preparation processes take longer and are more costly. Flexo printing is a high printing system, and it is a printing system that is widely used especially in corrugated cardboard and flexible packaging printing.*
In flexo printing, the main factors affecting quality are the material to be printed and its physical properties. In flexo printing, the main factors affecting quality are the material to be printed and its physical properties. In particular, the surface structure of plastic film and metallized packaging substrates with low surface energy is expected to be ink-retaining. Because the surfaces of synthetic plastic films and metallized foils have a smooth and slippery structure, preventing printing inks from sticking. Because the binder in the structure of the ink does not have a rough surface to penetrate. In order for plastic films to be printed, their surfaces must have certain properties. For this, surface improvement process called corona is applied to these material surfaces. With this process, the film material surfaces are made micro-rough and the ink adheres to the surface better and is more resistant to external factors. It should be borne in mind that the surface of a film material that has undergone a corona treatment may deteriorate over time unless it is printed on. Because the effectiveness of the corona treatment is time-limited and the surface energy inevitably decreases after a while. They are also affected by environmental conditions such as temperature and humidity.
In this study, to show the importance of corona surface coating, test prints were made with flexo printing on corona treated film materials whose corona became insufficient due to time. In the examination of the microscopic images of the test prints, it was observed that the ink adhered very well and was resistant to external factors on the surfaces where the corona treatment was adequately applied. On the other hand, it was determined that the ink color intensity decreased and the print quality deteriorated in the material with insufficient corona after the corona period.
As a result, in printing systems, the surface energies of the plastic films must be approximately 10 mN/m higher than the surface tension of the ink during the printing process, in order to maintain good printing quality and unchanged throughout the printing, and for this, the surface energies of the plastic films must be increased by corona surface treatment. demonstrated on test prints and microscopic images of prints.

Key words: Flexo printing, Corona treatment, Flexible packaging printing, Plastic films

1. INTRODUCTION

Flexo printing is a high printing system. The high image on the printing plate (the printed product) is transferred directly to the material surface in contact with the plate. The most important distinguishing features from other printing systems; the use of low-viscosity inks, the anilox roller that adjusts the ink volume, and the rubber-based elastic of the printing plates. The elastic plate allows high quality and very high volume printing (Figure 1) (Büyükpehlivan & Oktav, 2020). Flexo printing is one of the basic printing systems used in commercial printing production, and it is a very preferred printing type in packaging printing on high-volume plastic and metallized films with its print quality being improved day by day (Żołek et al., 2020; Abdel-Bary, 2003). Especially frozen foods, nuts, pulses etc. It is preferred for printing dry foods, liquid foods and plastic bags (Żołek-Tryznowska et al., 2020; Büyükpehlivan & Oktav, 2020).
In determining the flexo printing quality; In addition to the paper, cardboard, plastic and metallized films and ink properties used, environmental, mechanical, physical and procedural factors are effective. In addition, the compatibility of the materials used with the printing technique, the plate material and preparation, the improvements in the anilox roller, machine and control systems also affect the quality.

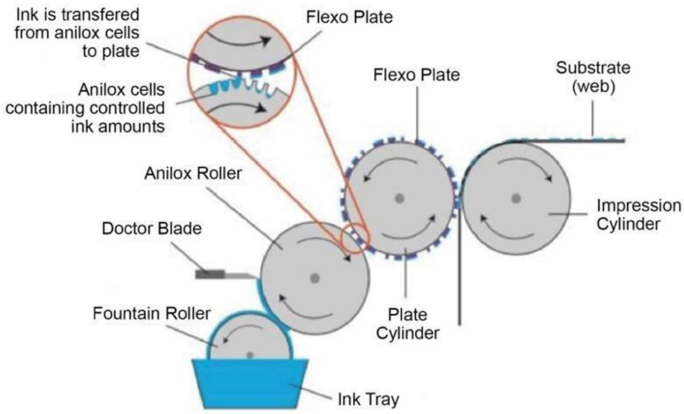


Figure 1: Flexo printing scheme (Wikimedia commons, 2022)

In flexo printing, with rubber-based flexible photopolymer plate, dots with 80% screen frequency and 3% screen ton value can withstand millions of pressures (Bould et al., 2004). The printing plate is prepared by completely computer-controlled exposure and solvent-free developing. The stages of the preparation process of the printing plate from design to printing and the physical properties of the plate made ready for printing have parameters that directly affect the quality. By transferring water-based, solvent-based and UV-curing low-viscosity inks onto the plate by means of an anilox roller, 3-5 micron-diameter dots are printed on the flexible printing material that can flow at a speed of 500 meters/minute in roll-to-roll printing machines. For a good print, there are very important quality elements that must be kept under control (Tomašegović et al., 2020; Ülgen, Oktav & Gençoğlu, 2012; Büyükpehlivan & Oktav, 2020).

One of them is that the surface energy of the substrate is desired and suitable. This shows the ink adhesion in printing, that is, the adhesion feature. Surface energy of the substrate; It determines the interfacial relationship and adhesion strength of the substrate material with ink and other plastic films (print job). In order to increase the surface energy of plastic-based substrates, corona treatment should be applied and controlled.

The surface tension of the plastic films and low viscosity inks used in flexo printing is the most important parameter in the material-ink interface relationship. Having these parameters at optimum values is essential for quality printing results. The corona treatment applied on plastic materials determines these optimum values. For this reason, a comprehensive examination of the corona process will contribute to the applications (Ülgen, Oktav & Çakır, 2019; Lindner et al., 2018).

Corona treatment is a process step defined in the industrial sector in 1951, developed after an engineer in Denmark was asked to find a safe way to print on plastic surfaces. This process is a method used to ensure that printing inks and lacquers adhere well to synthetic materials and metal foils. In the corona process, high-frequency electronic beam is applied to the synthetic material surface. Electron particles leaving the electron source quickly crash onto the flowing material. But before the electrons reach the material, they collide with the light-carrying air molecules; They partially react with ozone and nitrogen oxides. When electrons come into contact with the material, they dissolve carbon hydrogen and carbon bonds due to their high energy. Thus, ink and lacquers are easily adhered to the material (Figure 2) (Louzi & de Carvalho Campos, 2019; Pego et al., 2019; Jones, Strobel & Prokosch, 2005; Rocca-Smith et al., 2016).

The duration and severity of the corona surface treatment are determined by the chemical structure of the printing material and the surface tension difference between the material and the printing ink (Carradò et al., 2011). Corona treatment systems do this by applying a certain level of power to the surface for a certain period of time. This power/time parameter is measured in watt density, defined as watts/ft^2 (or m^2)/minute. Although the applied watt density is directly related to increases in dyne level (surface tension), the relationship is non-linear and depends on system and material parameters.

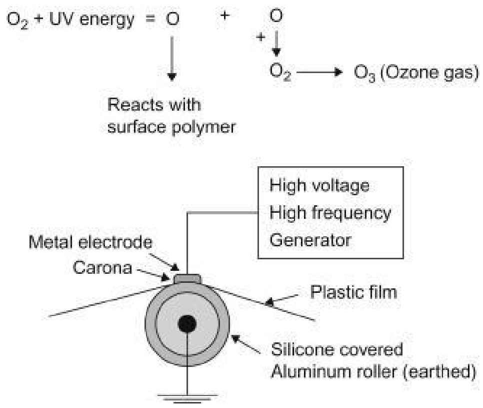


Figure 2: Corona Treatment System (Gilbertson, 2022)

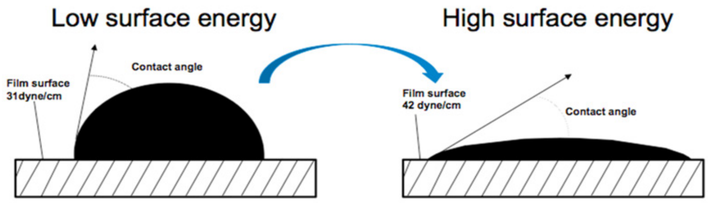
Corona density is the changing factor and can be calculated mathematically using the following formula (1):

$$Power = M * W * S * T \tag{1}$$

T – the number of sides that will be treated
S – the line speed, measured in m/min
W – the width of the film, measured in m
M – material factor, measured in watt/m squared per min (ZOi Films, 2022).

Corona surface improvement processes are not applied to all film materials in the same way. Different processing is applied depending on the type of material you plan to use. In order to ensure good adhesion, the surface energy of the printing material must be higher than that of the printing ink to be used.

As a general rule, when the surface energy of a printed substrate is greater than the surface tension of the ink by about 10 mN/m, a correct bond and adhesion can be established between the liquid and the substrate surface (Gilbertson, 2022; O'Hare, Leadley & Parbhoo, 2002). Since solvent-based printing inks have a surface tension of approximately 25 dyne/cm, it is clear that films such as PE (31 dyne/cm) and PP (29 dyne/cm) must be subjected to corona surface coating before printing (Figure 3) (Permabond, 2022; ZOi Films, 2022; Sun, Zhang & Wadsworth, 1999; Wegman & Van Twisk, 2012).



Material – Basic	Dyne/cm
PP	29
PE-LD	31
PE-HD	32
BOPP	32

Process - Application	Dyne/cm
Print – solvent based ink	40-42
Print – water based ink	46-48
Coating	44-54
Lamination	46-56

Figure 3: Plastik film baskı altı malzemeleri yüzey gerilimleri ve baskıda olması gereken yüzey gerilimleri (Permabond, 2022)

Corona surface treatment only affects the surface layer of the plastic film to such an extent that it creates micro-pits approximately 0.01 microns deep (Vetaphone, 2022).

The common point of these processes is that these films increase the surface energy. This leads to a better wettability as well as a higher bond strength (Brock et al., 2016). Plastic films most commonly used in packaging applications; polyethylene (PE, LDPE, HDPE, MDPE), polypropylene (CPP, OPP, MOPP, BOPP, metallized films), polyamide (PA), polyvinyl chloride (PVC), polyvinyldene chloride (PVDC), polyethylene terephthalate (PET) (Büyükpehlivan & Oktav, 2020; Wu et al., 2011). These materials, whose surface properties differ from each other, can be used alone or in a mixture depending on the characteristics of the product (Abdel-Bary, 2003; Plastik ve Ambalaj Dergisi, 2022).

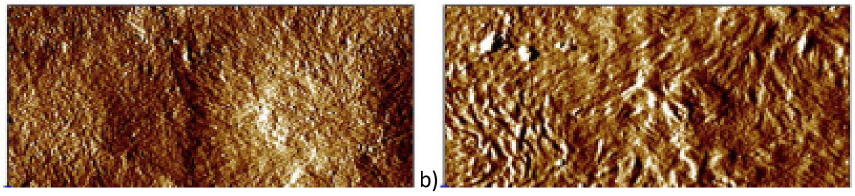


Figure 4: Untreatment (a) and Corona Treatment Surface (b) (AFM Images taken with AFM (Atomic force microscopy) (Popelka et al., 2018).

The higher the surface energy of a plastic film, the higher the bond strength of anything adapted to its surface. One reason for the low surface energy may be the property of the material. For example: many plastics have very low surface energy, so chemical or physical treatment is necessary to achieve good adhesion (Figure 4) (Wu et al., 2011; Villermet et al., 2003).
In general, the lower limit on these materials to be printed with flexo printing is 38mN/m. If the surface energy is lower than this value, the adhesion of the printing ink will be weak (Figure 5a), if it is above this value, the adhesion will be sufficient (Figure 5b). Therefore, for a good printing result, it is necessary to measure the surface energy of the plastic film before it is printed. Dyne corona pens are used to control surface energies. Using these pens is the cheapest, fastest and easiest way to check if a plastic substrate has sufficient surface tension for printing operations. This control method is always recommended to avoid having to scrap large quantities of substrate due to insufficient bad press (Vetaphone, 2022).

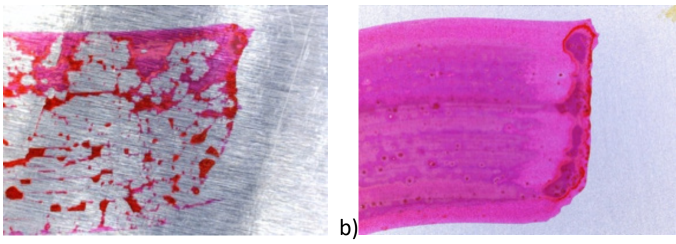


Figure 5: The image on the corona weakened surface (a) and well corona treated surface (b) using a 38 mN/m corona pen

2. METHODS

In particular, the surface energies of the materials used in flexible packaging should be approximately 10 mN/m higher than the surface tension of the ink. Otherwise, ink adhesion will not occur at the desired level and the expected print quality will not be achieved. In this case, the surface energies of flexible packaging need to be increased. Ink adhesion is related to the wetting properties of the substrate and ink materials. Corona surface improvement process is the most widely used roughening process, which gives good results on plastic-based printing films to improve ink adhesion and adhesion properties by increasing the surface energies of plastic films.
In the study, prints were made on polypropylene material, one of the most widely used plastic film materials in flexible packaging printing, to test the importance of ink retention, which affects quality. In the study, printing was carried out with 50 g/m2, 40 micron OPP material, Zahn 3 viscosity measuring cup and ink, the viscosity of which was determined as 20 seconds in ASTM D4212 standard. Test prints were made on the 10-color Omet X10 flexo label printing machine with the ability to make physical corona. A Corona test pen with a medium value of 38 mN/m was used to control the printing surfaces. Test prints were made on corona weakened and corona treated OPP film material. Microscopic images of test prints were taken with a Leica S8APO DFC295 stereoscopic microscope. In the study, the effect of corona surface improvement on the print quality is explained by examining the test print surfaces rather than theoretically.

3. RESULTS

In the study, firstly, prints were made on OPP film material with insufficient corona. When the friction pressure was applied physically on the printing surfaces, it was observed that the frictional strength of the inks was insufficient by means of a finger test. In addition, it was seen in stereoscopic microscopic shots that distortions in both solid tone and process printing and white holes in ground prints were printed on the OPP plastic film, the surface of which became unstable due to the corona weakened due to long storage time and adverse conditions (Figure 6). This caused deviations in the printing colors.

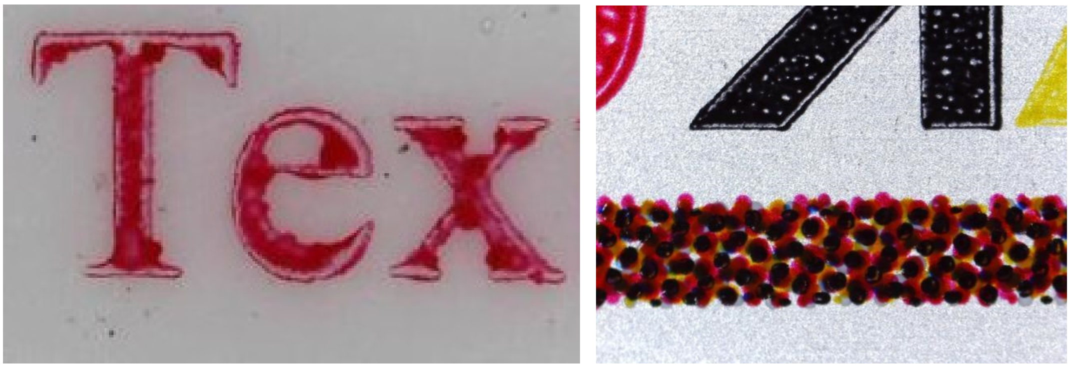


Figure 6: Examples of solid tone and process printing on OPP film material with weakened corona

It was determined that the printing results of both solid tone and process printing works were of the desired quality in the printing made on OPP with sufficient corona surface improvement (Figure 7). It was observed in microscopic shots that the ink adhesion to the surface was sufficient, and it was determined that the colors were in the desired and expected color tones.

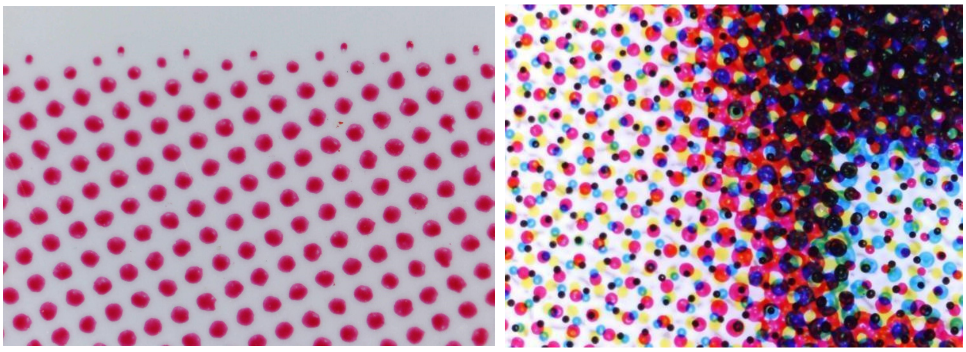


Figure 7: Solid tone and process printing examples on OPP film material with sufficient corona

4. CONCLUSIONS

In all printing systems, consistency at the beginning of the press and throughout the press is very important for quality. The physical and structural properties of printing materials, printing plates and inks, environmental, mechanical, physical and procedural factors are the main factors in ensuring consistency. The improvement of the printing quality specific to the flexo printing system; The knowledge and skills of the printing master depend on the anilox roller, scraper blade, machine and control systems.

Corona process usually is used for the treatment of polypropylene, vinyl foils, polyethylene, metallized surfaces, PVC, Paper and cardboard stock, PET and other similar material surfaces. These materials must have some features for printing and post-print lamination processes. For this, the surfaces of these materials must be treated with corona surface improvement. With the corona treatment, the material surfaces are made micro-rough and the ink adheres to the surface better. Printing is sometimes done on both sides of the material. In such cases, having corona on both sides may cause blocking of the prints. In this case, the prints must be dried very well.

The surface of a film material that has undergone corona treatment may deteriorate over time as long as there is no pressure on it. Because the effectiveness of the corona treatment is time-limited and the surface energy inevitably decreases after a while. They are also affected by environmental conditions such as temperature and humidity. Ink adhesion will weaken as the plastic surface will return to its original state. For this reason, if the corona treated plastic film has been kept for months for a long time before printing, the corona process must be repeated. Corona surface treatment can change the surface structure of plastic films and affect their adhesive properties. Increased surface roughness can result in increased or decreased adhesion depending on surface energies, potential bonding, and the presence of voids. Excessive application can cause bumps to form on the surface of the material and have a deteriorating effect on adhesion and wettability properties.

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