USING STATIC CREATIVELY IN PACKAGING

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INTRODUCTION

Mention static and most packaging companies reach for the tinsel and try to calculate the cost of the slow running it will cause. To be honest, the causes of static charges in most processes are well known and documented by the specialists, as are the solutions. The only real decisions for the processor are how to gauge the size of the problem, and whose equipment to use to control it.

However, static charges are not always a problem; deliberately induced, they can often be used to pin materials either to each other, or to machine rollers, in order to solve problems, improve efficiency and reduce costs. As this aspect of static control is not very well known, this paper is intended to introduce the principles and application of static pinning to a range of packaging processes and materials.

STATIC CHARGES

As this seminar is taking place at the Institute of Physics, it would be almost insulting to ignore the physics behind induced static charges and their effects, so here are the basics.

Electricity was originally discovered and researched with the aid of electrostatic phenomena which, in their pure form encompass only systems with stationary charges; i.e. those with infinitely high resistances and zero current. However, the present day term "electrostatics" is used in a much broader sense, and encompasses not only these traditional electrostatic phenomena, but also those elements of electrodynamics which have high voltages, very high resistances and very small currents. It is this broader field of electrostatics which forms the basis of most industrial applications of static charges.

The measure of electrostatic charge is the coulomb, or ampere-second, and the smallest degree of charge in nature is the electron, (e) with a value of e =1.6 x 10-19 C. Although each electron carries only a minute charge, they are very plentiful so larger charges are readily developed.

Electrostatic charges can be +ve or –ve and generate an electric field which can be easily measured. However, the most important aspect of an electrostatic charge is the force which it develops, for it is this which causes most problems in processing, but which can be controlled and used to enhance materials processing.

Electrostatic force is described by Coulomb's Law which, in its simple form can be expressed as:

F= 1 Q1 Q2

K r2

Where K is a material constant given by 4p e 0 and Q1 & Q2 are 2 charges separated by a distance r.

From this expression it is apparent that the greater the charges and the smaller the separation distance, the greater will be the forces acting between them.

In determining the magnitude of a charge, 2 factors need to be considered; the resistivity of the materials, and the charging mechanism.

The resistivity of a material largely determines the maximum charge density which can be achieved, (the saturation limit) as well as the rate of decay of that charge. Resistivity is a material constant with the unit 1 W m and has a wide range of magnitude, from metals at <10-8 W m to amber and quartz at >1016 W m. Materials with a high resistivity, including most plastics, generally have a higher charge saturation limit.

The charging mechanism familiar to most processors is tribocharging, where a charge is induced as materials are separated. However, for deliberate, controlled charging, a corona method is generally used, in which a high intensity electrostatic field is produced between electrodes positioned perpendicular to opposite surfaces of the material to be charged..

This field produces opposing polarities at the surfaces of the material and, if 2 surfaces are brought together between the electrodes, opposite charges are generated at the boundaries between the surfaces.

These opposite charges attract with the forces defined by Coulomb’s Law, causing the materials to become securely attached together until the charges decay. The more resistive the material, the higher the charge saturation limit and the slower the charge decay rate; the stronger the field, the higher the charge density and the greater the force. The forces of attraction produced by static charges are strong in shear, where force is multiplied by area, but weak in peel, where the force is acting along a narrow line and over a small area; these properties are used to advantage in industrial applications where we need to pin items either momentarily, or without them sticking to rollers and conveyors.

APPLICATIONS

Having established that we can stick materials together, or to grounded metal parts using static charges, what can we apply this knowledge to? Following are a few of the applications for static charging which offer measurable advantages in producing and processing packaging film:

Film Casting

Starting at the beginning, most packaging today uses plastic film which is cast from a die onto a chill roller. As soon as the liquid plastic film hits the chilled roller the edges detach from the roller and shrink, causing a phenomena known as "necking", where the edges reduce in width but increase in thickness. These necked edges have to be trimmed off and discarded, wasting not only the material (which can often be recycled) but also the energy used to process, transport, convey, melt and extrude the material. As the necked waste can be as high as 10% of the cast material, any reduction in waste will have a direct payback in increased efficiency. By using static charges to pin the edges of the film to the chill roller, necking waste can be halved, giving an immediate efficiency saving of up to 5% of processing costs.

Edge pinning electrode on film cast unit

Anti-telescoping electrode fitted before winder

Core Winding

Having cast the film with minimal necking, the finished web must be wound onto a core for transfer to the next process. Two problem may occur at this stage; attaching the film to the reel core, and uneven winding. .With a modern automatic reel stand, the change-over from full reel to new core is accomplished automatically at full machine speed. However, the cores still need to be loaded onto the reel stand, and a form of attachment, usually a glue or sticky tape, added to the core to ensure that the web attaches to the new core when it is cut. Again, static charging immediately before the core during the reel charge will stick the film securely to the new core without the need for tapes or glue; at the same time, the outer layers of the full reel and the ‘tail’ of the web will have been charged and will stick to the reel, maintaining tension in the full reel and preventing slackening of the outer layers or flapping of the loose tail as the reel slows.

A similar approach is employed to deal with both uneven winding and telescoping of the reel; with a controlled static charge used to counter web wander due to uneven cores or rollers, oscillations in the winding shafts, or even edge beads on the film. However, in this case the static charge is required throughout the winding process which, with some materials, can result in a very high accumulation of charge in the reel. In these cases, a high charge density is used to secure the web to one or more path rollers upstream of the winder, with discharging equipment used on the winder to reduce the charge in the finished reel to an acceptable level.

Modern microprocessor controlled charge generators such as the Eltex KNH series can be integrated with plc controlled reel winders to permit these two functions to be combined. The charge level would be set by the winder plc at a lower level to control uneven winding and then boosted to pin the web to the core during the reel change. Similarly, where film processing machines have plc controlled material parameters, these can be extended to automatically set the charge generators to match the material requirements. This makes the system virtually fit-and-forget, with the operator only needing to maintain the bars in a clean condition.

Printing Assist

Electrostatic Print Assist (ESA) is well known to most gravure printers in both the commercial and packaging sectors. However, as it is little known outside these specialist areas a brief description of its principles and practices follows:

ESA utilises the physical fact that electrically charged particles (such as gravure inks) are exposed to forces in an electrical field which always shift the particles into areas with higher field strengths. A simple plate condenser (Fig. 3) will help to illustrate this situation: When a voltage is applied, the plate condenser generates a homogeneous electrical field

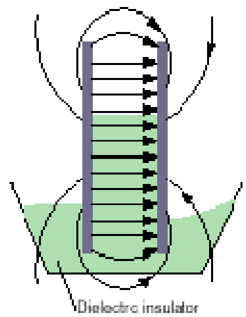


Fig 3 Dielectric Capacitor

between the plates which has a much lower field strength at the edges and outside the plates than between the actual plates. If this plate condenser is dipped into a tub filled with gravure ink, the uncharged ink particles turn into dipoles and migrate against the forces of gravity into areas with higher field strengths. The ink rises up between the plates until the weight of the particles and the force exerted on them by the electrical field are in equilibrium.

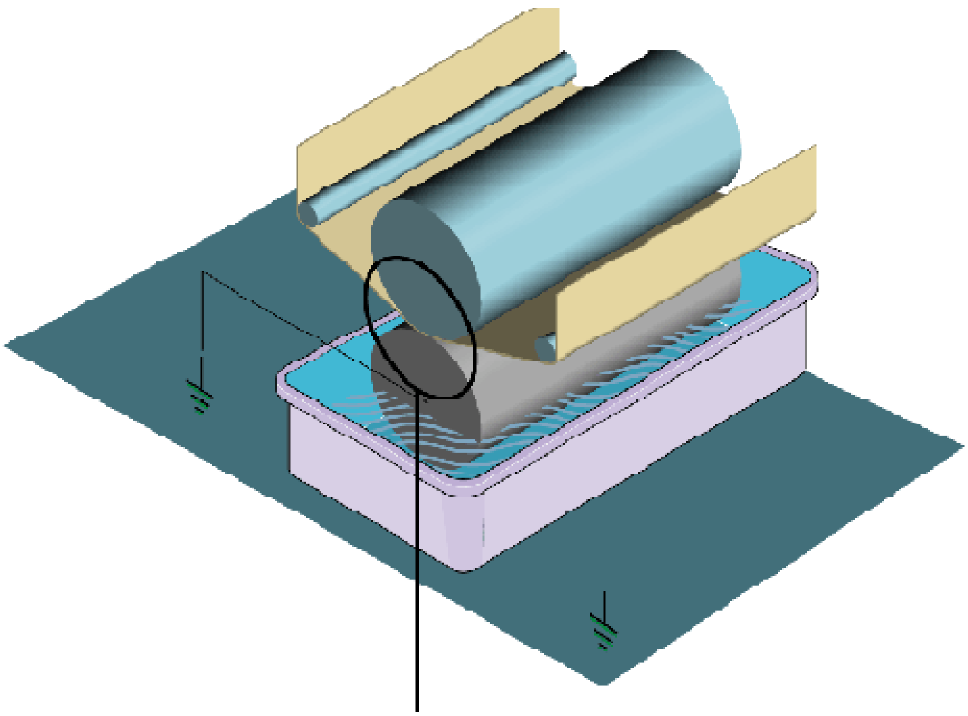
If this mechanism is applied to an ink-filled cell (Fig. 4), the electrical field at the edge of the cell will cause the ink to migrate to areas with higher field strengths. The ink leaves the cells and will contact the substrate to be printed, e.g. the gravure paper or film. In a printing press the electrical field is generated in the printing nip between impression roller and forme cylinder, whilst both the substrate and the ink are dielectric materials, i.e. insulators. To achieve effective ink transfer, electrical field strengths of 3-5 megavolt per metre are required. The electrical field strength is derived from Coulomb’s law as follows:

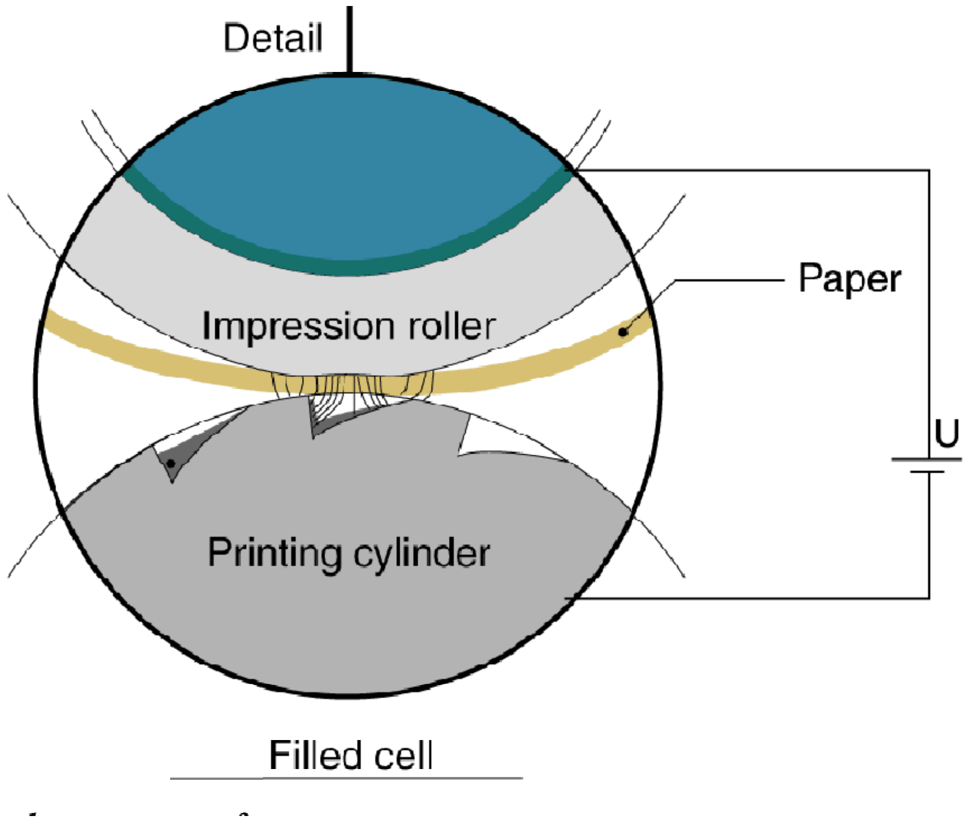
Electrical field strength º voltage

distance

With a distance of 0.1 mm, which is roughly the thickness of papers in illustration printing, the voltage required is between 300 and 500 Volts. This voltage is also limited by another physical variable, i.e. the breakdown strength of the substrate to be printed. The type of material, its density and its moisture content determine the breakdown strength, which is also measured in volts. The breakdown strength determines the highest voltage obtainable in the printing nip and hence the highest possible field strength. For example, illustration printing rarely uses nip voltages >500 Volts, because the breakdown strength of the paper is below this limit. However, voltages above 1,000 Volts are often found when printing films and board for packaging.

The primary benefits of ESA in gravure packaging printing are higher print speeds with lower impression roller pressures and high quality.





Printing Nip Detail

WHAT NEXT?

New applications for static charging are continually being introduced in plastics and film processing. However, three potential applications currently under development are worth a more detailed look:

Hygiene Work carried out by Arrowquint with dairy processors in Ireland and students from the University of Plymouth have indicated that some types of corona charging can significantly reduce surface living bacterial contamination of food and food packaging. Bacteria shown to be controlled by these static charges include E-Coli and Salmonella strains, as well as a variety of airborne mould spores. The Irish dairy processors found that milk products such as cheeses which were corona charged as part of the production process had a longer shelf life than the same products not subjected to corona charging. These effects have a similar biochemical mechanism to the cleaning effects of air ionisation investigated by George Richardson of AC&T Ltd, again in cooperation with the University of Plymouth.

Electro-Field Drying One of the major problems in drying fast moving webs is actually getting hot air to the surface of the web. The reason for this is that all surfaces moving through the air have an attached laminar boundary layer of air which virtually encapsulates the web and acts as an insulator. As a result, far more energy is needed to raise the temperature of the drying air and increase its velocity to penetrate this fast moving insulating layer, heat the web and create turbulence to allow released solvents to escape from the web. As a result, dryers are generally highly inefficient, with only marginal improvements coming from technology advances.

However, scientists at Eltex have found that low energy plasma stream will break up the boundary layer, creating turbulence and inducing dryer air into contact with the web whilst encouraging solvents to escape into the surrounding atmosphere. As a result, dryers can be redesigned to be smaller, more efficient and economical to run.

Preliminary results on Gravure dryers have shown that savings of 25% in size and of 50% in running costs should be possible by using electro-field dryers. Development is continuing with number of industrial partners, including Cerrutti, W&H and Bobst.

Flexo-ESA Eltex have long recognised that the electrostatic assist (ESA) applied to gravure printing may have an application in flexo printing and in coating. In order to develop this application further, they have entered into partnership with a major flexo press manufacturer to produce a commercial Flexo-ESA system. Flexo-ESA should offer higher running speeds with better quality control in both printing and coating applications using both solvent and water based inks.

For example, the coating system uses the existing ESA principle to ensure better ink transfer from an anilox type cylinder to the substrate, giving a more even and controllable coating.

CONCLUSIONS

Static charges are relatively easily induced into packaging materials. When induced by tribocharging in a relatively uncontrolled manner static charges generally adversely affect production or quality and need to be neutralised or controlled. However, by deliberately inducing charges in a controlled manner the associated forces can be used to aid production, improve quality and boost efficiency at relatively small cost. The processes and materials referred to in this paper are by no means exhaustive, as static charges are used in a wide range of other processes too numerous to detail. In the future, it is probable that some of the more obscure properties of static charges will be employed to further improve machine performance and product quality, whilst the main properties will continue to find new applications and to spread into new areas and industries.

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