PDS International Limited

SUBSTRATES

When we are involved in the mechanics and hydrodynamics of screen printing over a long period of time it is easy to take the substrate for granted. Ink use, machine operation, stencil production are all dynamic processes that require our attention. Substrate, the material we print onto, is a constant that comes into the print shop naked and leaves clothed in a limitless range of designs. In some cases the substrate is just a message carrying medium and in others it has a function where the message is secondary. At times both are of equal importance.

Probably the most unusual substrate I have printed on was a deep frozen ceramic paste. You would have to be eliminated if I told you what for. The most mundane being uncoated paper. All substrates have on thing in common and that is that the ink or material used to create the image must wet the substrate. This is where we come into the area of Surface Tension and Surface Energy. Even when printing onto woven fabric it of great assistance to obtaining a permanent print if the individual fibres are the right Surface Energy.

You notice I use the terms Surface Energy and Surface Tension. Surface Energy applies to a solid and Surface Tension to a liquid.

Whether it is sheet plastic or aluminium it has to be in a condition to accept the ink. This means it must be clean, but cleanliness is not enough it must have a surface energy that is high enough for the ink to wet it. Additionally the print mechanism depends on this relationship as the transfer of ink from the mesh openings to the substrate requires the attractive forces created by the different in surface energy/tension, but that is another topic.

What this means is that the surface energy of the substrate has to be higher than the surface tension of the ink. It is possible to check the surface energy applying liquids of known surface tension and seeing how they react on the substrate. Normally this is used on polypropylene or polyethylene that both require pre-treating before it will accept the ink. There are inks available with additives that mean it is possible to stick to the substrate without pre-treating but for arduous applications some materials have to have their surface energy increased.

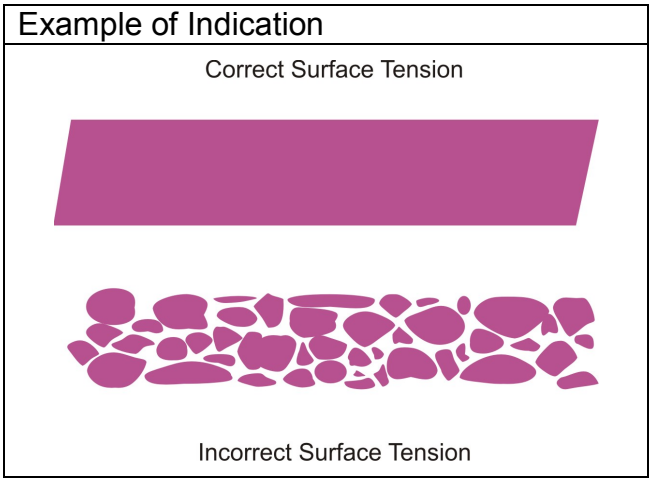
A test kit containing liquids of different surface tensions is used for this.

Surface Energy Test Kit

The liquids are classified as follows:

30 Dynes/cm-1	35 Dynes/cm-1	40 Dynes/cm-1
45 Dynes/cm-1	50 Dynes/cm-1	55 Dynes/cm-1

The surface energy of the substrate can be demonstrated by painting a streak of No 45 on the substrate and it should remain even on the coating for at least 2 seconds.



The optimum level of pre-treatment for solvent-based inks is 45 Dynes/cm-1
The optimum level of pre-treatment for UV based inks is 50 Dynes/cm-1

A streak that forms into beads immediately means the substrate has not been pre-treated and has a very low surface energy.

A streak that forms an even coating and then breaks up before 2 seconds shows it has not had sufficient pre-treatment.

A streak that forms an even coating that lasts for 2 seconds before breaking up into beads is correctly treated.

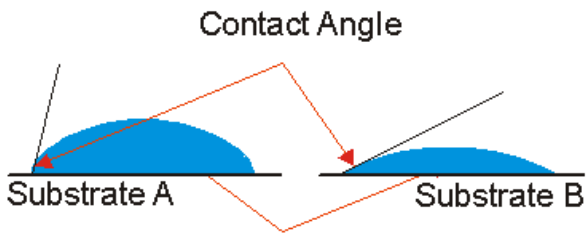
A streak that forms an even coating that lasts for considerably longer than 2 seconds has been over treated and you need to use a higher dyne value test liquid to check the actual surface energy.

A streak that forms areas of even coat and areas of beading has been unevenly pre-treatment.

Objective methods for investigating the wettability of a treated surface are available. Surface wettability is directly related to the contact angle made by a given liquid on that surface, and this contact angle can be measured by a contact angle measuring device. This allows reproducible measurements of the surface wetting characteristics of a variety of planar, solid surfaces. The results can be compared with those for liquids of known surface tension characteristics, to provide an indication of complete wetting, and the value of the critical wetting tension, of the surface under examination. The

measurement of contact angle can thus provide insights into the effects of additive migration, lack of adhesion to substrate, intercoat adhesion failure, and time-dependent surface changes.

Showing Two Different Contact Angles

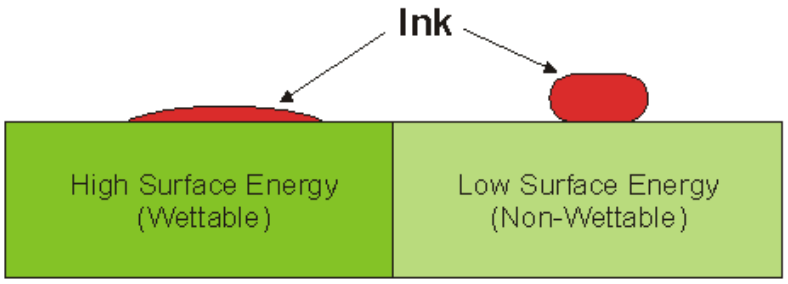


The instruments can be very straight-forward optical instruments or very sophisticated electronic units that will carry out a whole range of tasks allied to the measurement of contact angle. The sophisticated units are used particularly in the silicone circuitry device manufacturing industry.

PRE-TREATMENT

With some materials particularly polymers (plastics) and elastomers (forms of rubbers) it is possible to raise the surface energy by treating it with flame, corona discharge or liquid primer. Plasma treatment and Fluorination are two other methods that are not discussed in this article.

Effect of Surface Energy



LIQUID PRIMING

It is limited in the range of plastics that can be successfully treated. It is probably the least favoured method.

The fluids used are inconvenient to apply. Ideally this should be carried out by spraying or dipping. Care must be taken not to inhale the vapours or allow the fluid to contact the skin; constituents include Toluene and Xylene. It has varying effects on different materials and is not suitable for all. There are various primers. Experimentation is

necessary but even then selected changes in material batches can alter the effectiveness.

If the treatment is successful its effect will only last for 2 to 4 hours. With all pre-treated surfaces you must not touch them with your hand, as you will contaminate the surface. Liquid priming is not a process to be recommended due to the Health and Safety issues.

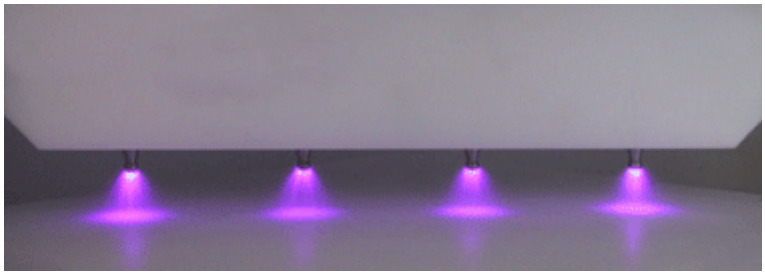
CORONA DISCHARGE

A high voltage discharge (spark), a form of plasma impinges onto the surface of the substrate and penetrates ionised particles into the molecules on the surface. The effect of this is to polarise the molecules and increase their attraction to the ink molecules. This alters the surface energy of the substrate. An electrode is ranged over the surface to be treated. Underneath the material is a receptor electrode. The distance between the electrodes is critical and it should remain constant. The high voltage discharge across the gap treats both sides of the material.

For mouldings that are effectively contoured sheet it is possible to fit them into shaped nests that contain the electrodes and treat them as flat film.

Selection of the means of corona treatment is dependent on the component to be treated. With all methods there is a drop off of treatment in the first 2-3 days. The ideal situation is to treat the item immediately before printing. Some sheet substrates will hold their treatment for several weeks or even months if stored correctly.

Discharge from Electrode onto Substrate



Cleanliness is essential when working with pre-treated material as it can be easily be contaminated by grease, oil mist or handling.

There must be adequate guarding to protect operators and it is essential that the Ozone generated is exhausted to atmosphere, as it is a highly toxic gas.

Corona discharge is most successful when used for treating film where the distance between the electrodes is reduced. There are some very sophisticated systems for three-dimensional objects that are very effective. These are used where high volumes can justify the capital costs.

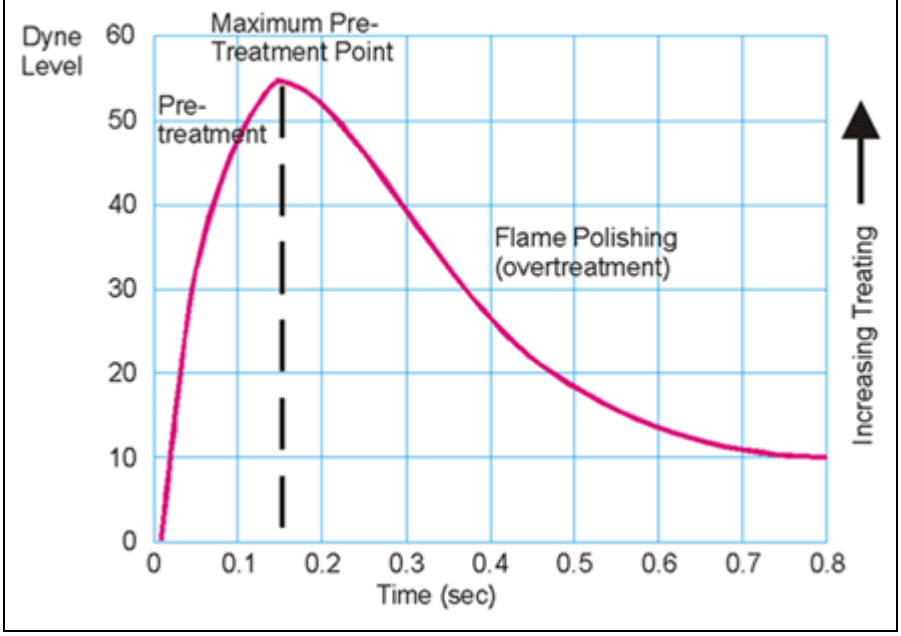
The process will not work if there is any break in the surface being treated, as the discharge will find the path of least resistance and short directly through the hole.

FLAMING

This is the most widely used method of pre-treatment. It is flexible and reliable if carefully controlled. It enables uneven and curved surfaces to be treated. It uses a mixture of air 20 - 50 psi and gas at low pressure 0.25 psi. The gas can be Butane, Propane, Natural Gas (Methane) and Coal Gas.

For the flame to be effective it must be oxidising, that is, blue.
There is a specific point in the flame that provides ideal conditions. This is called the Stoichiometric point. Correct flame control will give a wider treatment band.

Effect of Contact Time on Flame Treatment



Although some companies try to bodge up their own flaming systems unless they know exactly what they are doing it can be extremely dangerous and the insurance company will not look happily on the crater that appears in the shop floor.

There are first class systems available from companies such as Aerogen Company Limited of Alton in Hampshire. These have all the essential safety features and can control flame conditions effectively.

FUNDAMENTALS OF SUBSTRATE CARE

No matter what form of pre-treatment that is used to improve the wettability of a substrate the surface must be clean. Pre-treated substrate should be handled with

gloves as contact with the skin can contaminate the surface. Dust and debris will cause print faults and even damage the stencil.

With substrates that do not require pre-treatment care must be taken to ensure they maintain their printability.

TEMPERATURE AND HUMIDITY

Humidity can have a series of effects on substrates. Paper and board will absorb moisture if the Relative Humidity exceeds the moisture content of the material this will cause it to distort and could make it impossible to print. The ideal storage conditions are 50% Rh at 20°C

When paper or board are received the original packaging should be left on the pallet and the sealed pallet should be kept in the print shop for 24 to 48 hours for the temperature to stabilise with the ambient temperature. If the substrate is held in a store this should be kept at the temperature of the print shop.

Other substrates that do not absorb moisture should also be allowed to reach print shop temperature otherwise condensation will form on the surface of the substrate and compromise the adhesion of the ink. Be aware that the backing paper of self-adhesive materials can be affected by changes in humidity.

DIRT

Print shops should be clean! (Dream on) Never sweep with a broom. Use a wet mop and or industrial vacuum. Unfortunately many shops use hot air blower heaters. These are static generators and dust distribution devices. Try to use heating systems that do not move the air too much. Radiation, either gas of electric is much better.

Ionised air produced by anti-static devices correctly fitted will help reduce contamination of the substrate. Simple conductive tinsel passing over the substrate can also be very effective. Meech Static Eliminators and others can provide suitable solutions.

Adhesive roller systems that remove any loose dirt can be very effective. The initial investment can be high but they are great downtime reducers. TEKNEK in Scotland produce the market leaders.

CONDITIONING

When drying inks the heat generated can cause the substrate to alter in size to such an extent as to make printing subsequent colours impossible to register. To over come this it is recommended that the substrate is passed through the dryer set at running speed and output level before the first pass is printed. This is what we call conditioning. Some materials are pre-shrunk by producers but there is a cost penalty.

Careful printing of colour sequence can reduce the effect of substrate shrinkage and dryers can be modified to stop sheets feeding round the end roller. These are “Tricks of the trade” that can alleviate the problem.

Substrate suppliers have become much more aware of the markets they serve and can complement the technical support available from ink suppliers. There is no substitute for process expertise, which is becoming a decreasing asset in the screen printing industry.