PLASTICS NEEDING PRE-TREATED

Polyolefines is a name used for a range of plastics which are normally injection molded. Many of them are very suitable for printing such as polystyrene, A.B.S. and P.V.C. However plastics such as polyethylene, polypropylene will not accept print in their natural state. For a plastic to accept ink, it is necessary for it to be wettable by that ink. For this to be so, the surface tension or surface energy, measured in dynes/cm, must be greater than the surface tension (energy) of the ink.

Naturally, polyethylene, polypropylene have a surface tension of 30 dynes/cm. This has to be altered to be a minimum of 38 dynes/cm, preferably 42 dynes/cm. This can be achieved in three ways:-

1) By applying a liquid primer.
2) By corona discharge.
3) By flaming with a calor/butane/natural gas - air mixture.

LIQUID PRIMING

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

The fluids used are inconvenient to apply. Ideally by spraying or dipping. Care must be taken not to inhale the vapors or allow the fluid to come in contact with the skin. Careful reading of the Health and Safety Data Sheets is essential. 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.

CORONA DISCHARGE

This process uses a high voltage discharge. An electrode is ranged over the surface to be treated in a line. Underneath the material is another receptor electrode. The distance between the electrodes is critical and ideally it should remain constant. A high voltage is generated (several thousand volts) and the discharge arcs between the two electrodes producing a plasma. This ionizes the surface of the material to be treated, thus altering its surface tension. The process is clean and relatively safe.

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 which 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 Oxidizing, that is, blue.

There is a specific point in the flame that provides ideal conditions. This is called the Stoiciometric point. Correct flame control will give a wider treatment band

It is recommended to use the specially designed flame control systems. These are fitted with gas and air control valves to compensate for pressure fluctuations ensuring that the mixture is always at its optimum.

Safety devices such as flame failure are fitted as standard. Automatic ignition is also normal.

Flame nozzle design is important and these are normally single or double row ribbon burners. This will give a more stable flame shape and characteristic. "Flame throwers" are inefficient and unreliable. Flame control and position of the item in the flame are critical. Setting up the flamer is very important.

Checking the results with a test kit are essential.

Overflaming will damage the surface of the product and along with under flaming means the ink will not stick.

Speed of the substrate through the flame greatly effects the level of pre-treatment. As a rule the higher the speed of passage of the item through the flame the less likelihood there is of damage to the surface. High gloss surfaces are susceptible to blooming which reduces the gloss. Higher speeds help reduce this.

Conveyers are constructed from metal mesh. Ensure they are of sufficient length to allow the mesh to cool. Hot meshes will mark plastic components.

Take advice from the flaming equipment supplier. With all methods of pre-treatment regular monitoring of treatment level is essential.

PLASMA TREATMENT

Cold gas plasma technology is emerging as an efficient way to treat polymers, dramatically improving their surface properties for high performance printing, painting and adhesive bonding. In some cases plasma provides the only acceptable solution to

these common surface treatment problems. Very difficult materials such as certain types of silicone rubbers can be printed using this pre-treatment process.

Gas plasma is the fourth state of matter. Analogous to the liquid gas transmission. If a gas is given enough of the right type of energy it can be excited to become an ionized gas or plasma. Recognizable examples include the Solar Corona, lighting, arc welding or fluorescent light bulbs. Common to all is the glow discharge admitted when the excited ions return to their ground state.

FORMS OF PLASMA

There are three forms of plasma:

1) Hot.
2) Mixed.
3) Cold.

It is the cold plasma that is used for pre-treating polymers.

METHODS OF PRETREATMENT

The items to be treated are placed in the treatment unit. The pressure is then reduced and small amounts of particular gases, normally oxygen, are fed into the chamber. The radio frequency generator is turned on striking the plasma and the surface treatment then takes place. There is other equipment which enables a continuous process whereby for example insulated wire, fabric, tape, tubing or other similar products are fed through a chamber which is sealed to control the leak rate between chambers and assure controlled reduced pressure in the reaction chamber. For many materials the resident time of less than one second is sufficient for complete treatment. A typical use would be the preparation of insulated wire for improved adhesion of inks or coatings. Bulk pretreatment systems are available for containers and closures. These work on a similar principle and can be very effective. They do not require a vacuum and can be found in large volume molding shops.

PLASMA SURFACE TREATMENT AND ADHESION

To prevent contamination after treatment, parts should not be handled with bare hands. (This applies to all forms of pre-treatment). Clean cloth gloves are recommended as rubber gloves may transfer residual processing aids or oils to treated parts. Shelf life of treated material can be relatively short, and if necessary a priming layer may be needed to protect the treated surface. Plasma treating will give a much improved bonding strength, often stronger than the material itself. It is considered to be the most effective means of pre-treating polymers with bonding strengths four or five times that of Corona discharge and flaming.

TESTING FOR CORRECT PRE-TREATMENT

To enable checks to be carried out on pre-treated surfaces, it is necessary to establish the amount that the surface tension (energy) has changed. This is best done by applying a glycol-water mix of a specific surface tension. These mixes can be contained in glass bottles and applied by brush or more conveniently by felt tipped pen.

If the mixture spreads evenly across the surface, then satisfactory pre-treatment has been achieved. If, however, the liquid forms into globules, then the pre-treated surface has a surface tension less than the glycol-water mix applied.

TEST KITS

Kits normally consist of 6 to 8 mixes giving indications of surface tensions from 28-56 dynes/cm. This testing method can be applied to pre-treated surfaces no matter what form of pre-treatment is being used. It is imperative that the lids be firmly replaced after use. Gloves and goggles should be worn to prevent contact with the skin and eyes.

FELT TIP PENS

Test fluids can be supplied in the form of felt tip pens, these are adequate for determining a minimum level of treatment. Both methods use hygroscopic fluids, it is imperative that the lids be firmly replaced after use. Gloves should be worn to prevent contact with the skin.

Always read the Health and Safety Data Sheets very carefully before using.

RUNNING WATER

A rule of thumb is simply to hold the object under running water. Upon removal the water will show even wetting followed by slow dewetting.

On an untreated surface the water will form globules.

SCOTCHTAPE

Another simple test is to heavily mark the component with a ball pen. Stick a strip of clear Scotchtape on the mark and strip off. Correct pre-treatment will show most of the ink adheres to the plastic. This is not ideal and should only be used as a last resort.

MEASUREMENT OF CONTACT ANGLE

An objective method for investigating the wettability of a treated surface is now 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, and 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.

The instrument is supplied with lead, sample holder, syringes, manual, glass slide for calibrations, and a program for calculations on a floppy disc. It uses a beam of light from a narrow filament source to illuminate the surface of a liquid droplet placed on the test sample. Substrate samples are cut to 40 x 75mm, or less, and are handled with tweezers, and a sessile drop is placed with a fine syringe. Using the eyepiece, a scan is made to locate the bright spot which is the virtual image of the filament in the droplet. The sample is then rotated towards the light source until the image just disappears. This point defines the contact angle, and is shown on the display. The software runs on an IBM PC or compatible computers, and is menu-driven. It calculates the surface tension of the sample from the contact angle measuring device readings, and allows results to be printed.

IDEAL LEVELS OF PRE-TREATMENT

Untreated polyethylene and polypropylene have a normal level of around 30 dynes/cm. Successfully treated PP and PE, for printing purposes, should demonstrate a level of around 38-42 dynes/cm.

OTHER FACTORS AFFECTING ADHESION

Treatment level is a decisive factor for the adhesion of printing inks onto PE and PP. There are, however, other factors such as the migration of slip (additives which can affect adhesion), but whose effects cannot be detected when measuring the level of treatment. It is, therefore, possible that printing inks will not adhere despite favorable results when testing the treatment level.

It is also possible that surfaces with the same treatment levels will give varying degrees of print adhesion.

The effect of pre-treatment will reduce over time some will last for months others only for hours. So much depends on how the pre-treated material is stored. If in doubt carry out test prints before printing a batch. In any case test adhesion regularly during the print run. Keep clean and avoid contact with the bare hand. Operators should wear cotton gloves.