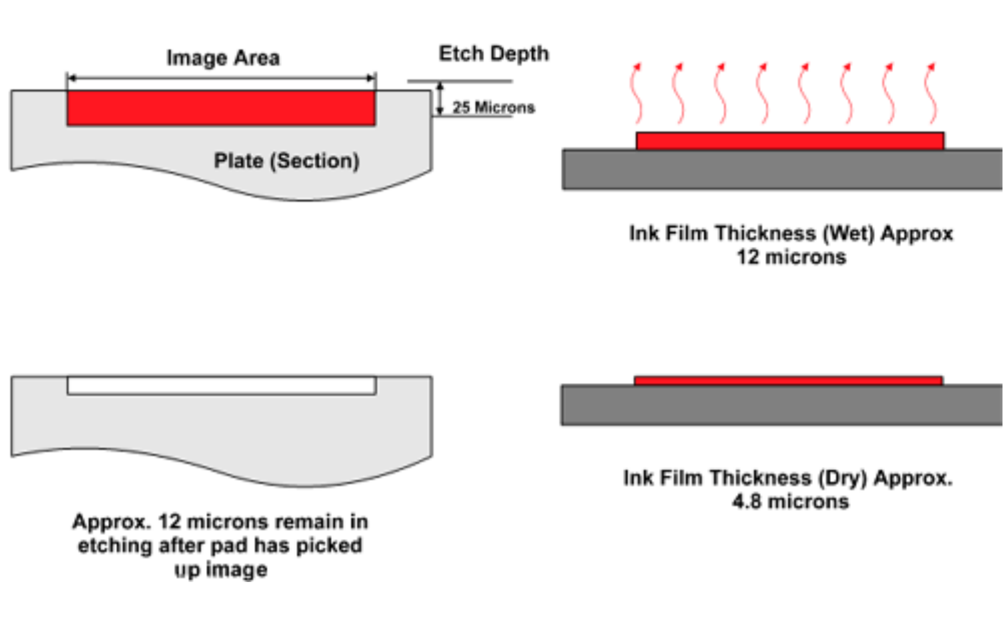
PAD PRINTING INKS
PDS International – Peter Kiddell

Let's make it clear right at the start I am not an ink technologist or even a chemist. This article is from the printer's viewpoint. It will deal with ink selection, ink mixing, simple chemistry. Having read the article, you will know more about pad printing inks than most ink reps. It will explain how they behave and why sometimes they appear to misbehave the inks that is not the reps!

Inks are formulated to transfer an image from the printing plate to the surface to be printed. They are used to convey a message or decorate an object. There are times when they can be used to conduct or resist the flow of electricity, carry pure gold, store magnetic messages or simply be invisible. The vast majority of Pad Printing inks are designed just to transfer colour.

Most pad printing inks are based on screen printing inks. Unlike screen printing inks they do not have the advantage of being applied in thick films. With screen printing ink film thicknesses of 30 microns are easily attainable however pad printing has to work with much reduced ink deposits.

TYPICAL INK FILM THICKNESS



INK MANUFACTURE

At its simplest a pad printing ink consists of a mixture of the following components:

- Resins
- Pigments or Dyes
- Solvents
- Minor additives, e.g. flow aids

RESIN

This is the component of the ink, which is primarily responsible for the formation of the finished ink film, and the carrier for the colouring material used in ink formulation.

Typical examples of resins are PVC, Alkyd, Polyester and Epoxy.

Inks may be designed to produce systems, which dry by solvent evaporation, polymerisation or other methods depending on the precise resin structure.

PIGMENT

The pigment imparts the colour and opacity to the finished print and is usually supplied in powder form. It has to be incorporated into the ink by the ink manufacturer using a mechanical dispersion process, (e.g. triple roll mill, ball mill). A commonly encountered pigment is titanium dioxide, obtained from a naturally occurring mineral. This pigment is intensely white and has the particular property of imparting great opacity to any system into which it is incorporated. Titanium Dioxide is often used to create pastel shades by intermixing with coloured pigments.

Several factors must be taken into consideration when the ink producer selects an appropriate pigment; these include light fastness, wash resistance, cost, and toxicity.

DYES

Unlike pigments, dyes are materials, which are capable of dissolving into the ink medium, and as a consequence of this dissolution such inks have good transparency. Dyes are normally more expensive and have lower resistance properties than pigments. These are the main reasons why dyes are limited to specific applications.

One area of printing where dyes are used in preference to pigments is in textile printing. Dyes may be selected which chemically combine with the material being printed, eliminating the low resistance disadvantage, and thus giving the finished product good resistance properties.

SOLVENTS

The function of the solvent is to enable the resin-pigment mixture to be transferred to the substrate via the printing process. As discussed in past articles the evaporation of solvents is critical to the pad printing process. Unlike screen printing where the speed of evaporation of solvents needs to be relatively slow so the ink does not dry in the screen. Pad printing requires fast evaporating solvents to enable the ink to transfer. The advantage of this is that multi colour printing is possible on the same machine.

The exact choice and amount of solvents will depend on the resins and pigment used in the ink, and in a number of cases, on the nature of the substrate.

For most inks it is impossible to find a single solvent which will fulfil all the demands made on it, normally a mixture of solvents is used, selected on the basis of their individual properties.

Inks supplied may by design not contain the amount of solvent or the type of solvent required. This is to enable the printer to "fine tune" the system to suit the ambient conditions.

MINOR ADDITIVES AND FLOW AIDS

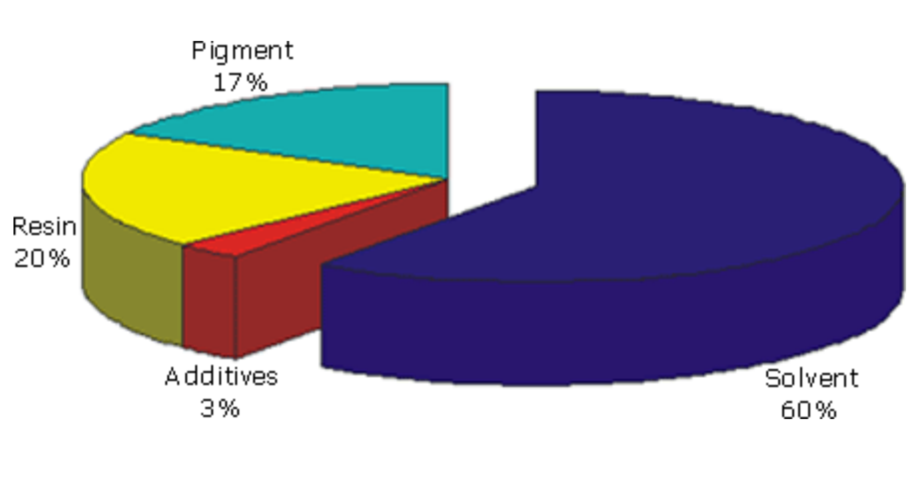
The properties of ink produced by mixing only resin, pigment and solvents is unlikely to produce a system, which is satisfactory in use.

The major defects in such a system are likely to be brittleness, poor film strength, pigment separation and unsatisfactory flow.

To overcome such problems one or more minor items are added to the ink system at levels of between 0.001% and 10%. Additives such as plasticisers and surfactants are used to improve flexibility, flow, pigment stability and are thus essential for the adequate performance of the ink. Other additives such as thixotrops are used to tailor the ink for specific purposes where, for example, a property such as flow must remain within certain limits, (e.g. tri-chromatic system).

Additives such as barium sulphate or calcium carbonate can be added as fillers to reduce the cost of the ink while still maintaining its essential properties.

TYPICAL COMPONENTS OF SOLVENT BASED INKS (MIXED READY FOR PRINTING)



INK SYSTEMS

The ink systems currently available to the industry fall into eight different categories:

1) Solvent Evaporating.
2) Oxidation Drying.
3) Reactive (Catalyst Curing. Two component).
4) Stoving Inks.
5) Ultra Violet Light Cured (Solventless Inks).
6) Water Soluble.
7) Sublimation.
8) Ceramic and glass thermoplastic inks.

SOLVENT EVAPORATING SYSTEMS

These inks make up the major part of pad printing ink production. They dry only by solvent evaporation; that is to say when the solvent has evaporated from the deposited ink film. Care must be taken when printing non-absorbent materials with this system, as absorbency is required to give best adhesion. Solvent evaporating systems are available in gloss and matte finish and dry very rapidly. Solvent ink systems perform particularly well with many thermoplastics. A guide to their suitability for a particular plastic is to rub the solvent used to thin the ink onto the plastic. If it melts the surface of the plastic the chances are the ink will adhere very well.

OXIDATION DRYING INKS

In these systems the resin in the ink absorbs oxygen from the atmosphere and undergoes a polymerisation process producing a very tough, flexible weather resistant ink film. Because of their slow drying speed, inks of this type are usually allowed to dry in the air. They are limited in their application for pad printing due to their slow drying.

TWO PACK OR REACTIVE (CATALYST CURING INKS)

These inks also contain resins capable of polymerisation. However, the required catalyst is normally either blended into the ink or else supplied in a separate pack, which may be mixed with the ink when required. If blended in the inks have a restricted shelf life. They may be cured rapidly by heating. Two pack inks are used extensively in pad printing

They are generally applied to difficult substrates for example, metals, thermoset plastics, glass, etc. Where good chemical and abrasion resistance is required these inks are very popular.

Particular care must be taken when mixing the base ink with the catalyst. The ratio specified by the ink manufacturer is by weight. Therefore these inks must always be weighed during mixing. There are no exceptions. Inaccurate mixing can give differing ink adhesion and product resistance characteristics.

Another important factor to be aware of with these ink systems is that after printing and prior to complete curing the temperature of the printed ink film must not drop below 15 Degrees Centigrade. Should this occur the ink will cease curing and cannot be restarted. This may not be a problem if the ink is force dried with heat, as the curing may nearly be complete. However if curing takes place in storage over a period of time the ink film is vulnerable. An ink film is not necessarily cured when it is dry. It takes time or temperature or a combination of to effect a complete cure. Typically 5 Days at 20 degrees Centigrade or 10 minutes at 100 Degrees Centigrade. This information is available on the ink Technical Data Sheet, which, unfortunately most users do not bother to read.

STOVING INKS

Stoving inks can be influenced regarding the elasticity of the ink film. They need a certain minimum temperature and time to cure within the minimum and maximum temperature of curing. The cure time varies which means that the higher the temperature, the shorter the drying time. Equally important is that if the ink film is more elastic, the lower the temperature.

ULTRA VIOLET (UV) LIGHT-CURABLE (SOLVENTLESS) INKS

This is a system widely used in screen process inks. It offers the printer faster curing speeds, ease of printing and fewer of the environmental problems normally associated with solvent-based systems. Extraction is necessary to remove the Ozone, produced by the light sources, out of the building to atmosphere, although these emissions are now restricted due to the Environmental Protection Act.

Care must still be taken when handling these systems and the normal precautions regarding direct contact with skin, eyes, and ingestion apply. In addition as the ink does not dry without intense UV Radiation, it will transfer upon contact.

Most of the major pad printing ink suppliers are carrying out developments to produce a UV ink suitable for the pad printing process. I am aware of at least 4 who have field trials running at the moment. The initial target market is the Compact Disc Industry. This rapidly expanding market (in excess of 20% year on year) is constantly searching for more effective ways of printing the discs. Audio CD and CD ROM are becoming even more colourful this need is being addressed with seven colour screen printers and offset printing machines. The use Pad printing in the CD industry has, in recent years, been declining. This development could bring new life into the use of Pad printing onto CD's.

Machinery suppliers have been working with ink manufacturers to develop a UV Curing Pad Printing Ink. The author has been made aware of equipment that is claimed to run at 4000 prints per hour using this system.

There are applications where UV Curing inks have solvents added to them to enable them to perform as conventional pad printing inks in the transfers from plate to pad and pad to substrate. This system is used when a hard over-lacquer is required to protect an ink from abrasion. Keyboards are a typical use of this technique.

Precise details regarding ink technology and application are still somewhat sketchy however, information received indicates that the process operates as follows:

As the inks cannot contain solvents the normal tackiness achieved with conventional inks is not possible. However the pad still has to pick the UV curing ink out of the plate this is done by modifying the rheology of the inks to give the necessary tackiness. When the pad comes down onto the plate and its surface comes into contact with the tacky ink surface the ink sticks to the pad and when the pad lifts it causes a percentage of the ink in the etching to shear away from the remainder of the ink. This will only be approximately 6 microns of ink. When the ink comes into contact with the substrate it releases from the pad because of its silicone content. The deposited ink is then cured with high intensity UV light and as there are no solvents in the ink the dried film is the same as the wet film. The depth of the etching on the plate would be about 20 microns. It is important to ensure that the thickness of the ink film is controlled otherwise curing will be very difficult.

This is still in the experimental stage and different manufacturers will specify different pad materials, hardnesses and etch depth of plate. It is unlikely that the range of substrates printable will be as extensive as conventional solvent based inks.

As with conventional UV curing inks ink opacity is compromised. It is likely that a white background will be necessary to give the intensity of colour required. Considerable testing is essential before putting the technique into production. The big advantage of this system is that it is not affected by small changes in ambient conditions and will give much greater stability to the process. It is likely to be most popular for use in four colour work where thin films of transparent ink are necessary for satisfactory results. In this case a UV curing station has to be positioned after printing and before the next print. It may be possible to modify existing machinery that has intermediate hot-air drying but the intensity of UV light required would mean that considerable shielding would be necessary to protect operators. More details will be available in the near future.

WATER SOLUBLE

With the awareness of the dangers of exposure to harmful solvents and the consequent introduction of regulations, e.g. COSHH and the EPA industry is attempting to move away from solvent based systems. It is unlikely that they will ever be suitable for pad printing, as the speed of evaporation is very slow.

SUBLIMATION

This is a process where a solid turns into a gas when heated. Sublimation inks make use of this characteristic. When applied to an appropriate surface and the temperature of the ink and the surface is raised to approximately 200o C dyes in the ink sublime and the surface of the material becomes porous and the dyes pass into the material.

This actually changes the colour of the base material.

Polyester, polythene, acetyl, and some nylons are most suitable for this, as they need to be able to withstand the high temperatures.

Once the material has cooled the ink is sealed into the surface. The wear characteristic of the ink is equivalent to that of the base material.

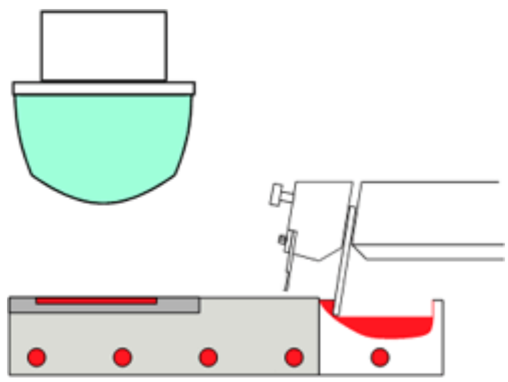
Care must be taken in the selection of colours, which are limited, as certain inks are sensitive to UV light and fade very quickly.

Another limitation is that the background material colour must be lighter than that of the ink. The range of colours is very limited and matching to Pantone colours is almost impossible.

Pad printing is a suitable process for this system, as ink deposit must be kept to a minimum otherwise the colours will bleed.

CERAMIC AND GLASS THERMOPLASTIC INKS

EXAMPLE OF INKING MECHANISM USED FOR PRINTING THERMOPLASTIC INKS



The use of these systems has proved to be very successful for pad printing onto glass and ceramic. It uses the system developed for screen printing onto glass, where at ambient conditions the ink is in a solid form (rather like candle wax). When the ink is raised to 80 Degrees Centigrade it is fluid. Unlike conventional pad printing ink the pickup and print is not by evaporation of the solvents but by the cooling effect of the pad when it comes into contact with the ink in the etching on the plate. Similarly the ink transfers from the pad to the substrate because the ink surface exposed to the air is tackier than the surface on the pad. A complete transfer is achieved by the cooling effect of the substrate, normally glass or ceramic. This process enables fairly heavy deposits of ink to be printed. The etch depth is greater when using this ink system. 30 to 50 microns. Once the item has been printed the ink has to be fired onto the surface at approximately 580 Degrees Centigrade for glass and 1200 Degrees Centigrade for ceramic. In glass printing the firing chamber is known as a lehr and in ceramics printing a kiln. This area is a topic all of its own. A certain amount of success has been achieved with solvent systems carrying ceramic pigments, but the thermoplastic system is the most popular. These inks are dishwasher safe. If this characteristic is not necessary Stoving and Reactive Curing inks are very effective for printing onto glass and ceramic.

INK SELECTION

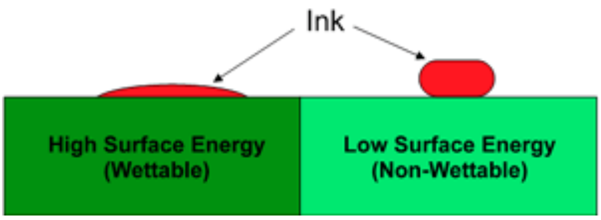
All manufacturers provide their customers with help to find the correct pad printing ink. The Technical Data Sheets supplied by all ink manufacturers state which materials are suitable for printing with that ink type and any special requirements i.e. pre and post-treatments.

To enable the correct decision to be made regarding the selection of inks, it is necessary to be aware of a wide range of conditions and requirements. The statement 'I wish you to print a blue ink on this plastic component' poses a whole range of questions that must be answered to fulfil the application satisfactorily.

If a surface is to accept ink it must be wettable by that ink. For this to be so the surface tension of the ink must be lower than the surface energy of the substrate. See Figure 4.

Contamination, in the form of oil, grease, silicones, condensation etc. will inhibit or stop ink wetting the surface. Cleanliness is essential.

INDICATION OF THE EFFECT OF SURFACES THAT ARE WETTABLE AND NON-WETTABLE



SUBSTRATE

It cannot be overstated the need to accurately identify the substrate as small changes in the chemical composition can radically affect the surface of the material. The most difficult situation is where surface conditions will vary at different points, or throughout a production run. Plastics that are filled, (i.e. glass filled nylon, talc filled polypropylene), often demonstrate the characteristics of the filler rather than that of the plastic as there is a tendency for the filling material to be at a higher concentration on the surface of the plastic. In other cases, the surface of a plastic will change when slip additives come to the surface. This is particularly so where heat is applied to a moulded component.

The effect of slip additives coming to the surface can be that the ink will simply fall off after apparently having obtained a good key.

PLASTICS NEEDING PRE-TREATMENT

Polyolefines is a name used for a range of plastics, which are normally injection moulded. Many of them are very suitable for printing such as polystyrene, ABS and PVC. However plastics such as polyethylene, polypropylene and polythene 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.

Polyethylene, polypropylene, and polythene 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

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

The fluids used are inconvenient to apply, ideally by spraying or dipping. Care must be taken not to inhale the vapours or allow the fluid to come in contact with the skin. It has varying effects on different materials and is not suitable for all. There are various primers available. 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 ionises 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.
An alternative to this method is where components are bulk treated in a chamber that is charged with electrical plasma. This is a very effective method and will treat every surface of a moulding no matter what the shape. It is however really only suitable for large numbers of components as the capital cost of the equipment is quite high.

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 p.s.i. and gas at low pressure 0.25 p.s.i. 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.

Correct flame control is very important. A basic flamer will do simple work but for regular use and long production runs it is recommended to use 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.

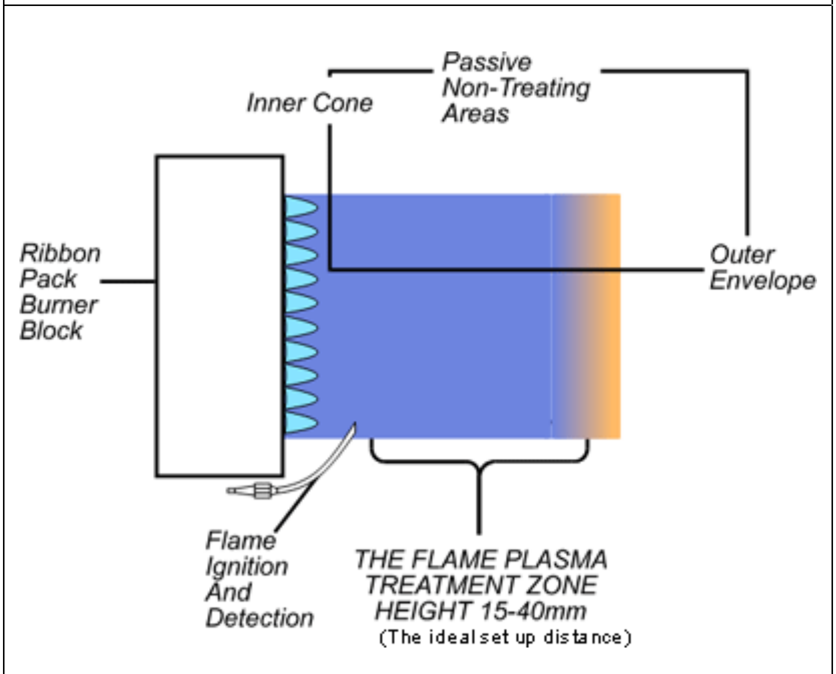
Flame nozzle design is important, and these are normally single or double row ribbon burners. This will give a more stable flame shape and characteristic. "Flame throwers" are inefficient and unreliable. Flame control and position of the item in the flame are critical. Setting up the flamer is very important.

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

Speed of the conveyer greatly effects the flaming. 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.

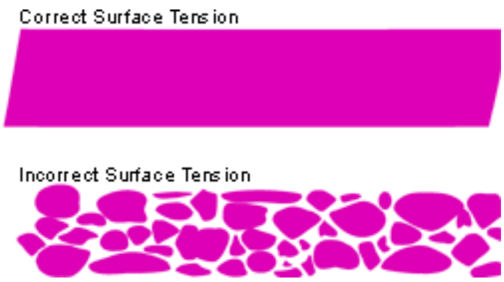
IDEAL FLAME SHAPE



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.

EXAMINATION OF SURFACE ENERGY USING TEST FLUIDS



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. Applying a glycol-water mix of a specific surface tension best does this. 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.

Checking the results with a test pen or test kit is essential.

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.

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 de-wetting.

On an untreated surface the water will form globules. SCOTCH TAPE
Another simple test is to heavily mark the component with a ball pen. Stick a strip of clear Scotch Tape 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.

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 favourable results when testing the treatment level.

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

If Polyolefines are being printed and no pre-treatment is available, then primer less inks should be considered. Efficient post-treatment in the form of either infra-red drying, hot air drying, flame drying or UV drying, will make ink selection much easier, as all of these processes will enhance the final characteristic of the relevant ink system. A typical example of this is printing onto polyoxides, such as Delrin. Here, single part ink can often be used as long as it is post-treated with a flame. Without this, the highly stable structure of the material makes satisfactory adhesion impossible.

PROPERTIES OF CURED INK

It is necessary to know how the ink is expected to perform under varying conditions.

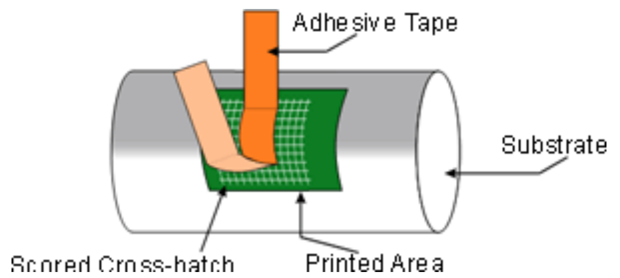
COLOUR
The starting point is either a sample of the colour applied to the surface to be printed and/or a reference to a standard colour specification, such as Pantone, Din, British Standard, etc. The subject of colour matching is complex and will be dealt with at a later date. You must be aware that the ink film in pad printing is very thin and often there is a need to print on a coloured background that will affect the final colour of the ink. Always check the printed colour under different lighting conditions. Stability of colour under UV light is very important. Manufacturers will give undertakings on their data sheets as to the stability of pigments.

ADHESION AND RESISTANCE TO ABRASION

Scotch Tape tests, rub tests, tabor wheel tests, etc., should all be specified before selection of the ink. The classic comment of 'it mustn't scratch off' is not acceptable, as this scratching can be carried out by metal, plastic, or a fingernail. A fingernail is the most variable, as some people appear to have remarkably hard nails, which not only remove the ink but the surface of the substrate.

A recognised adhesion test is to cut a crosshatch through the ink with a blade in 4 mm squares. Scotch Tape is then applied and removed with a sharp pull at an acute angle to the surface. The amount of ink remaining determines the level of adhesion.

ADHESION TESTING



ADHESION PROBLEMS & RECTIFICATION

Lack of adhesion can be a major problem. Be sure the ink sticks.

<u>Investigations</u>

- It is important if adhesion problems arise to check the following points:
- Is the molder using a mold release?
- Is the moulder adding any plasticisers?
- Has the moulder changed % of filler?
- Is the moulder using re-grind material?
- Is there any grease or oil on the surface?
- Is the operator wiping the printed area with a hand or finger and leaving greasy areas?
- Have the mouldings been stored at a low temperature and then brought into a higher temperature? (This will cause unseen condensation on the surface).
- Has the material been changed without informing you?
- Are you using the correct ink?
- Has it been weighed out and the correct hardener and ratio of hardener used?
- Has the right thinner been used?
- Has anything been added by mistake i.e. methylated spirits, water?
- Was the ink well stirred in the tin prior to mixing?
- Has the ink shelf life expired?
- Has the ink been left in the machine too long?
- Should you be pre or post-treating?
- If pre-treatment is carried out, have the correct dyne levels been achieved?

RESISTANCE TO CHEMICAL ATTACK

This can be withstanding the effects of oils, solvents, acids, alkalis, or plain water. Probably one of the most arduous applications is a dishwasher where there is a mixture of detergent, alkali, and hot water. I am not aware of any non-ceramic ink system that will withstand this application for extended periods. Another surprisingly aggressive material is melted snow. This contains a whole cocktail of chemicals that are collected as the clouds form and the snow falls through the atmosphere. Back to environmental issues again. Always check what your client needs the printed ink film to withstand before you start printing. Firstly read the Technical Data Sheet provided by your ink supplier. If in doubt carry out ink trials and provide printed samples for your client to approve. If necessary, ask your ink supplier to run trials.

WEATHERING

Again the Technical Data Sheet will give you information on this subject. If it is critical then it is possible to carry out accelerated weathering tests on the printed substrate. There are independent laboratories available if your ink supplier is unable to carry them out for you.

SINGLE OR MULTI COLOUR

This can determine the speed of drying of the ink. Correct selection of solvents is important, for example when printing multi colours wet on wet it may be necessary to use a faster drying solvent for the first colour printed, an intermediate for the next and possibly a retarder in the last colour.

FOOD AND TOY GRADE

The level of toxicity of pigments and resins in the inks are very carefully controlled. These applications are anywhere where the constituents of the ink may be ingested. Heavy metals such as cadmium are totally unacceptable and the regulations are constantly becoming stricter, so advice should be taken from the ink supplier.

POST PRODUCTION PROCESSES

Once an item is printed it often has to go through other processes, which will affect the printing.

OVER-LACQUERING

With this the ink normally has to be fully cured and unaffected by the solvents in the lacquer. Part curing will cause the lacquer to lift, and incompatible solvents will mean that the ink will bleed into the lacquer.

This technique is used when printing some keyboards. In this case however the lacquer is Ultra Violet curing and a solvent is added to the lacquer to give it its transfer qualities so that it will work on the pad printing process. UV Curing lacquer is used because it forms a very hard layer that protects the ink from abrasion. The lacquer solvent mixes are rather crude, and they do not make for easy printing without considerable care.

HEALTH AND SAFETY

This is the most important issue addressed in this article. The terms inks, thinners, retarders, cleaners all have a fairly harmless ring to them. It is easy to be complacent about their effects and potential hazards. They are all chemicals and some of them, if handled incorrectly, will have lethal consequences. With the growth of legislation in this area industry has become much more sensitive to work induced illness. This is particularly the case in the use and handling of solvents. There are still horror stories and I have come across instances where companies have exposed their employee and the general public to materials that will result in certain damage to health and even premature death.

There is simply no excuse for this. Suppliers of inks and solvents provide all the necessary information about safe handling and storage of their products in their Health and Safety Data Sheets. It is essential that all personnel who come into contact with these potentially harmful substances read and understand the health and safety data sheets before they handle the substances. If you are reading this article and using inks and solvents in your facility make sure everybody in this situation is aware of the Health and Safety implications. There are no excuses. Failure to do so can lead to illness, even death and result in criminal prosecution of the company or the individual responsible for ensures best practice is adhered to. Health and Safety is the responsibility of everybody in the workplace.

ENVIRONMENTAL ISSUES

If we continue to abuse the environment at the current rate in a very few years the planet will be unable to cope with the abuse. As with Health and Safety the Environment is everybody's responsibility.

Current legislation defines the responsibility of the company and the individual. The areas of a printer’s responsibility are: -

- Disposal of waste or redundant inks and solvents.
- Disposal of cleaning products (tissues and wipers) contaminated with above.
- Control of emissions into the atmosphere. Volatile Organic Compounds (VOCs), particulate matter (dust) and certain gases. Ozone being one of them.

Different states and countries have varying levels of legislation. Infringement of this legislation can result in severe fines or even imprisonment.

If you are unsure about how you have to dispose of waste materials talk to your suppliers. They are duty bound to provide you with the necessary information. Alternatively contact the local Regulatory Authority. You can find who they are through your Town Hall.

Companies have a Duty of Care to ensure that their waste products are disposed of correctly. As with Health and Safety there are no excuses for not following the recommendations and legislation.

BEST PRACTICE IN INK MIXING

Having control of the evaporation of solvents from the ink and the balance of those solvents in the ink is the most important element of successful pad printing. Ink manufacturers spend vast amounts of time and money developing and formulating inks for us to use. What do some of us do? Pour the ink from a tin into the ink reservoir without checking the label on the tin. Squirt in some solvent, move the inking mechanism back a couple of times to mix in the solvent and then try to print some components.

When the ink doesn't transfer or if it does the ink doesn't stick, what do we do but blame the ink! Of course it is not our fault it’s those idiot ink makers who never get it right. After all whichever ink is used it is always rubbish. Another batch to be tipped down the drain!

Really, let us try again. Imagine it is a new job.

Q1 What material is the substrate
A1 15% Glass filled Nylon 66.

Q2 What is the colour of the substrate
A1 Black

Q3 Finish of substrate
A3 Gloss

Q4 Colour of ink
A4 Pantone Orange 021C

Q5 Finish of printed ink film
A5 Gloss

Q6 Test requirements
A6 Cross hatched 0.1 inch grid. Scotch Tape applied less than 10% removed Resistant to 10 rubs of a 1 inch square felt pad soaked in petroleum spirit. With a force of 2 pounds applied

These factors would indicate the need to use a reactive curing two component ink with some form of forced drying. This is likely to give the level of adhesion necessary and withstand the rub tests. It will also be necessary to apply several prints probably 3 to get the density of this bright orange on the black background. A gloss finish to the ink is achievable because the substrate is gloss.

Forced drying is used because this enhances the cure of the ink film and stops dust collecting on the surface before it dries. The means of forced drying is a conveyor with a variable speed drive this has long wave infrared heating elements mounted over it. Long wave (black heat) is used because it is not colour sensitive. Short wave infra-red heaters (spot lamps) are colour sensitive in that the heat would be adsorbed by the black substrate and reflected by the light coloured ink. The heating unit should have air circulation to remove the solvents driven off from the ink. There should also be sufficient unheated conveyor to allow the ink and component to cool prior to packing. You could use a static oven, but the conveyor has the advantage of taking the printed products away from the operator. The trials not only established the method but also the mix of solvents in the ink to give optimum printing performance.

ON TO PRODUCTION

The operator is given the production control card. That details all the setting instructions and ink solvent mixes. Having gathered together all the elements necessary to set up the job the ink is mixed.

The operator puts on additional protective clothing. Goggles, gloves, and an apron if necessary.
Read the labels on the ink, hardener, and solvents to ensure they are as specified on the production control card. Also checks the date to ensure that they are not outside their use by date.

The tin of ink is opened, and the contents stirred vigorously to ensure that it is well mixed. The hardener is also opened and stirred. A suitable container is placed on the scales and the stated amount of ink is weighed in. The hardener is then added to the correct ratio, by weight, and stirred in. Then the mix of solvents is added, and this is carefully stirred to ensure complete dispersion in the mix. At this stage some people will use a visco-spatula that gives a guide to viscosity. If your mixtures are correct by weight the viscosity will be acceptable in any case. The specified amount of ink is then poured into the ink reservoir. The remainder used for replenishing ink later on in the day is kept in a closed container. The other machine settings are made as per the production control card and, surprise the machine will print first time.

Assuming the solvent balance is maintained during the day with addition of measured amounts of solvent at specified intervals, it will run right on through. Depending on the ink system selected and the ambient temperatures, the ink will have to be completely replaced with a new batch in 8 to 10 hours time. This is because the ink will be curing as it is in the ink reservoir and would have changed its print characteristics by that time. In very high ambient temperatures it may be necessary to change the ink more often. Accurate estimation of ink used during the day is important, as mixed ink not used should be disposed of correctly and is expensive to waste. If you had been using an ink that did not use a catalyst the ink could be used for a much longer time as it does not cure in the ink tray. I would still recommend that it is changed after 48 hours, as there can be a buildup of contaminants in the ink that could alter its properties. There also may be chemical changes if the inks are Oxidation curing. Often, I hear printers say, " If I use fresh ink it improves the print".

Reactive (Two component) inks are not recommended for use in sealed ink cups as they gel if they are not agitated and will cure off completely if left in the cup for extended periods.

Care must also be taken when using reactive inks on screened plates as any trace left in the etched portion of the plate overnight will cure and be impossible to remove the next day. This applies to a greater or lesser extent with any part of the machine or jigging.

RULES OF USING INK

- Read the Technical Data Sheets.
- Read and understand the Health and Safety Data Sheets.
- Always wear protective clothing, gloves, goggles, when mixing inks.
- Ensure there is adequate ventilation at all times.
- Stir ink and hardeners before use.
- Use only specified solvents.
- Weigh the ink, solvent, hardener, components, and mixture.
- Do not use inks or hardeners that are past their shelf life.
- Seal partly used tins of ink their shelf life is reduced once opened.
- Keep unused mixed ink in a closed container.
- Do not use mixed two component ink after pot life is expired.
- Do not use two component inks in closed cup printing systems.
- If single component ink is used continuously change every two days.
- Never mix ink types to achieve a colour match.
- If ink splashes onto your skin wipe off excess with tissue or cloth and the wash with soap and water or proprietary hand cleaner.
- Never use thinners to remove ink from skin.

- If ink or solvents enter your eye irrigate with water for 15 minutes and seek medical advice immediately.
- In cases of swallowing do not induce vomiting seek medical advice immediately.
- In both the above cases take the Health and Safety Data Sheet and the Technical Data Sheet to the medical authority.

COLOUR

Colour is a huge subject the following section gives the elements of the subject that impact on basic pad printing.

There are seven factors, which determine how a colour is perceived:

1) Colour of ink.
2) Colour of substrate.
3) Ink film thickness.
4) Matt or gloss finish.
5) Surface texture of substrate.
6) Viewing light.
7) The ability of the viewer to differentiate between colours.

PERCEPTION OF COLOUR

It is first necessary to understand how we perceive colour. If white light strikes an object, part of the optical spectrum is absorbed by the object, while the rest is reflected. This phenomenon is called 'diffuse reflection'. Our eyes catch some of these reflected beams, which are then translated into pulses and transmitted, to our brain. Our brain converts these pulses into the perception of colour. This means that each colour is perceived and assessed subjectively by each individual person. The pigments and other constituents of the ink absorb most of the white light and reflect only the colours that we see. A given colour of ink will perform differently depending on the range of influences upon it.

COLOUR OF SUBSTRATE

If you were to take two extremes, black and white, white is the ideal background colour because it will reflect the maximum amount of light through the ink and allow the most accurate interpretation of the colour. Black on the other hand, absorbs a great deal of the light and causes an interpretation which is much duller and flat compared to ink printed onto a white background. The lighter the colour of the substrate, the more it is going to lift the colour of the printed ink. One would expect that contrast in colour would be the most noticeable, but this contrast is only effective if the printed colour is backed with white.

Therefore, to achieve a bright colour on a black background, it is necessary to print down as intense a white as possible and then overprint it with the required colour. Even if this is done, the colour appears different than if it had been printed on a completely white background. It must be realised that background colour will dramatically alter the brain's perception of a colour printed onto it.

INK FILM THICKNESS

The heavier the deposit of ink the less is the effect of the colour of the substrate. Here pad printing is much inferior to screen printing due to the fact that pad printing only has a dried deposit of 4 - 6 microns of ink, whereas screen printing can put down a dried deposit of up to 30 microns of ink. Varying thicknesses of film will produce different colours.

MATT OR GLOSS

As mentioned above, the reflective qualities of an ink determine its colour. The surface finish, therefore, either matt or gloss, will lift or dull the colour.

SURFACE TEXTURE OF SUBSTRATE

This will affect the surface finish of the ink, as, for example, a gloss finish is very difficult to achieve on a fine texture without increasing the ink film thickness to compensate for the texture.

VIEWING LIGHT

There are three basic types of light:

1) Daylight.
2) Artificial light viewed under a tungsten filament lamp.
3) Artificial light viewed under a fluorescent lamp.

There are obviously an infinite number of alternatives, but these are the three basic ones that are accepted in the industry. As we only see what is reflected, if certain wavelengths are not produced by the light source, then they cannot be seen. The temperature of the source determines the wave length emitted by a light source. The lower the temperature, the yellower the light. The higher the temperature, the whiter the light. Classic examples of low temperature yellow light are sodium vapour, which are commonly used as street lamps now. High temperature light is, obviously, sunlight, which is daylight. Details of this are shown in Figure 1. Therefore, an identical ink mix will show as different colours under varying light conditions. The most extreme case that we all see nowadays is the orange sodium vapour lamps that have turned our streets at night into a monochrome. The shape of an item will affect its perceived colour because shadows are made up of reflected light from other surfaces. It is sometimes necessary to specify the lighting conditions under which the colour should be viewed.

This is particularly the case when there is a likelihood of a combination of pigments being used to create a colour match. They can be the same colour under one type of light, but when viewed under another type of illumination, the colours do not match. This is known as a metameric match. When they are correct under all conditions, then this is a spectral match.

THE ABILITY OF THE VIEWER TO DIFFERENTIATE BETWEEN COLOURS

Here, we are in the realms of colour perception. A large percentage of the population is either partially or totally colour blind and it is being proved experimentally that a person's perception of colour will alter as their mood changes. For example, when working under stress, the darker colours in the spectrum become more noticeable to the viewer than the bright colours, and vice versa. Equally, of course, colours can affect a person's mood. Because of this a standard has to be agreed for all lighting conditions. This is done by colour matching.

COLOUR MATCHING

Historically, colours have been matched by skilled printers who, with a palette knife and a selection of colours, mixed to obtain the desired colour. This is a slow and costly process.

There are colour standards Pantone is probably the best known. This system gives thousands of colours with mixes. Unfortunately from the pad printers' point of view these are based on printing onto white coated or uncoated board. They do give a target colour and sometimes it is necessary to print white down first to achieve the specified colour.

The next step was to mix inks from base colours by weight to a specific formula. This method is more efficient but still relies on the individual to interpret the colours achieved. Nowadays, sophisticated computer programmes are available that utilise the output from a spectrophotometer to determine the precise formulation of a colour match, using standard colours.

Once the ratios are achieved, they are then weighed out, firstly as a trial batch and then after testing, as a quantity for the full production run. For users of large quantities of ink this system can prove to be very cost effective. It enables excess inks which would normally be thrown away to be used in other formulations as long as they have been stored in closed containers, weighed, and entered on the system.

IN CONCLUSION

Without ink we do not have a printing process. In pad printing it is an element that is constantly abused. Ink manufacturers trying to provide satisfactory ink spend a great deal of time and money. The user can then destroy all this good work by not following the basic rules set out in this article or even bothering to read the technical data sheets.

Always carry out tests on the substrate before going into production. Materials do change and problems can occur. If a print operator or machine is covered in ink, then somebody is not doing their job properly. Remember inks and solvents are chemicals and if you don't treat them with respect, they could do you and or the environment considerable harm.