We have come a long way since the use of multi-fibre silk meshes when it was "Silk Screen Printing" to today's "Mass Imaging Technology." Surprisingly at the time when silk was being used so was woven steel mesh. Silk has now disappeared except in some esoteric artistic applications where the artist wishes to capture the essence of the ancient methods.

What makes screen printing so attractive to production process engineers is the ability to apply a controlled film thickness over large areas relatively quickly and yet with precise positioning. In the graphics industry the material printed is a printing ink with a coloured pigment or dye that has to be adhered to a wide range of substrates for visual effect. Being able to control the ink film thickness and the precise position and shape of the image is crucial to the final appearance. Top quality four colour process work has all the qualities needed for the production process engineer, precision and consistency being the two main characteristics.

Being engineers the users of screen printing in industrial applications take it as a given that the equipment has to be precision machinery. They know that variations in speed, pressure and alignment will alter the lay-down of material. Where they start their examination of the process is normally with the drying and curing. There is no point in printing substrate at a frantic pace if it is not practical to dry and cure the printing medium (ink). It is not just a matter of drying and curing, how it is done can be crucial. There are very specialised methods that use electron beams and microwave or even flaming to dry materials but the common ones are:

RADIATION CURING - ULTRA VIOLET LIGHT AND INFRA-RED

Both UV and Infra Red energy are part of the Electromagnetic Spectrum they start at either end of the Visual Spectrum. (ROY G BIV) Both types of radiation are used in drying and curing processes. Infra Red energy creates heat.

- **Ultra Violet Energy** does not have to have a heating effect although most emitters produce heat (Infra Red) energy as a by-product of producing UV. Efforts are often made to filter out the heat with water cooling, quartz filters and air movement to eliminate distortion of the substrate. Light Emitting Diodes (LED's) produce cold UV but they are restricted in their spectral range. With UV heat is sometimes used to assist the cure. The spectral range is the wavelengths that an emitter produces. These need to be matched to the chemistry of the printing medium to affect a full cure.
- **Infra Red Curing** comes in three categories, Short Wave, Medium Wave and Long Wave. Short Wave is closest to the visible spectrum and is recognised by it being combined with a lot of white light. The emitter looks like a spot light. Medium Wave is further away from the visible spectrum and the emitter glows red. Long wave is the furthest away and the emitter does not give off any light. The effect of short wave curing is dependant on colour of the material and its reflectivity. Medium Wave is not so dependant and Long Wave Infra Red is not affected and will penetrate more deeply into a film that the other two.

THERMAL CURING - FORCED AIR AND CONDUCTION

- **Forced Air** is particularly suited to drying solvent based systems. The heat in the air drives off the solvent molecules and the moving air removes them from the surface of the film. If the flow is fast enough the temperature created by compressing the air is sufficient heat.
- **Conduction** is when the substrate carrying the printed film passes over a heated platen. This will dry the film from bottom to top and can be very efficient. It is also used in combination with moving air.

These normally take place in conveyor systems or on the web. Occasionally static ovens are used but this is a method that puts a dwell in what should be a continuous process.

Whatever method is used control, measurement and recording are a key part of the process. It is not just a matter of, is it dry? How it is dried is often vital as chemical reactions whose completion is key to the end product take place. At its simplest this may be solvent evaporation from the printed film. Too intensive an initial drying can lock solvents into the film below a dried surface. At a more complex level polymerisation caused by radiation or thermal curing has to be completed in a specific time frame to give the final film the desired characteristic. Sometimes this isn’t the final cure as additional layers have to be applied and a fully cured film can be impossible to stick to by subsequent films if it is fully cured. At other times it is necessary to keep oxygen away from the film whilst it is curing as the combination with oxygen will alter the finished product. To overcome this inert gas such as nitrogen is injected into the drying chamber and this displaces the air and shrouds the curing surface. In the absence of oxygen the curing process can continue without contamination. Contamination can take other forms, one being dirt, to overcome this incoming air has to be filtered sometimes to submicron levels. Many of these applications are in clean rooms but the drying curing zone has to be cleaner still. All these factors mean that with any dying/curing requirement that deviates from a simple application considerable thought has to be given to the equipment even before you select the printer, as how fast you can dry the material could determine the overall production rate.

Quality of the stencil is another very important element of some forms of industrial printing. The stencil is a mesh stretched on a robust frame with a photosensitive emulsion applied that is then dried, exposed and washed out (developed.) Once developed the stencil is carefully inspected for faults and then filled in any non printing areas that are still open mesh. So how does that differ from a conventional screen printing stencil you may ask? The difference is precision. Precision in every aspect of production. From selecting the frame that is dependent on the mesh specification, the tension, image size and off contact distance. The frame has to be strong enough to maintain its stability within the tolerance of the process. That means that any distortion in the frame does not put the image or film thickness outside their tolerance. An unstable frame will distort the image and change the off contact distance that will in turn alter the printed film.

Mesh has the greatest effect on film thickness. It meters the printing medium on to the substrate. The theoretical ink volume of the mesh in cubic centimetres per square metre is a guide to the wet film thickness, it equates directly to the film thickness in microns. The mesh technical data sheet gives a lot of useful information it should be used whenever a mesh selection is made. The mesh specification does not just stop at mesh count. The tension applied to the mesh is dependent on mesh material, mesh specification, mesh elongation, off contact distance, size of image and the strength of the frame. The key issue is to work within the elastic range of the mesh so that it will maintain its tension over a long period. Remember that the deflection of the mesh allowed by the off contact distance is increasing the tension. Ideally the mesh should lift away from the wet film as soon as the squeegee has passed a given point. If the mesh lays in the wet film it will not allow an efficient passage of medium from the mesh. Mesh tension is the hidden energy source of the screen printing process and it should be measured in the middle and four corners of the image area. Deviation of more than 1 Newton Centimetre for most applications would disqualify a stencil.

Stencil emulsion over mesh (EoM) and roughness (Rz) are two other key aspects of the stencil. The thickness affects the build of ink at the edge of the image and the roughness impacts on the edge definition. If liquid emulsion is being used then for good edge definition additional wet on dry coats should be applied to level the print side of the stencil. Alternatively use of the latest capillary films that provide high frequency roughness that stops the stencil sticking to the substrate but effectively provides a very flat stencil giving excellent edge definition and controlled EoM.

An area that is often ignored is the stability of the photopositive. High humidity will cause the photopositive to stretch whilst low humidity will make it shrink. High temperature will cause it to stretch whilst low temperature will make it shrink. The image setter on which it is produced would have controlled conditions, these are available and deviation from these will enable a user to calculate the changes. Using computer to screen imaging can resolve some of these issues but there are other factors to take into account not only the capital cost.

So there we are we have briefly looked at drying and curing and the stencil without even examining the condition of the printing medium, the machine the handling of the substrate and its suitability for printing. Not to mention setting the squeegee and flood coater or both their characteristics. So much to take into account but there should be it is an engineering process after all.

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