SCREEN PRINTING

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PRINCIPLES OF SCREEN PRINTING

The process is known as screen-printing. Silk screen-printing is a name first used when the mesh or screen was made of natural silk. It can also be known as "Serigraphy" particularly when used for creating or reproducing fine art, the word comes from the Latin "Seri" (silk) and the Greek word "graphein" (to write or draw).

Nowadays screen mesh is either made from polyester or stainless steel. Silk is only used when individuals, particularly artists or art historians want to copy the techniques used for many hundreds of years prior to the production of polymer mesh in the twentieth century. Going back some two thousand years it was the Chinese who first used human hair stretched across wooden frames to support leaves cut into shapes and stuck to the hair mesh to form a stencil. Later the Japanese adopted the process and started using woven silk as the mesh and producing the image on the stencil by the application of lacquers. It was Samual Simon from Manchester who, in 1907 patented the first industrial screen-printing process. Near the beginning of the First World War, John Pilsworth of San Francisco developed what became known as the “Selectasine” method. This method produced multi-colour prints from one screen. Areas on the screen were blocked out after each colour was printed, and the screen was reused for the next colour. Commercial shops exploited this cheap technology to produce quantity signs and posters in colour.

Although an ancient skill used in fabric decoration, the production of religious texts and printing playing cards its use as an industrial process is relatively new. As with many techniques the basic process remains the same but how the machines and equipment are now configured would be unrecognisable to Samuel Simon. The introduction of electronics and Programmable Logic Controllers have produced a further step change in the process, turning it from a craft into an engineering process that is measurable, controllable and predictable.

The basic items of equipment required to carry out screen process printing are:

STENCIL: This is a structure that consists of a frame onto which a mesh is attached under tension. The mesh is coated or covered with a photosensitive material. The image to be printed is created photographically on the stencil leaving open areas of mesh through which ink passes. The Stencil is also known as “The screen”.

SQUEEGEE: a flexible polyurethane (sometimes rubber) held in a rigid mount or handle.

INK: Can take the form of a wide range of solids or dyes suspended in a fluid. There is a wide range of ink chemistries available to suit a vast range of applications.

SUBSTRATE: This is a general term for the surface that is to be printed. The surfaces can range from bread to bio-medical sensors.

MACHINE BASE: the base provides a surface for the substrate to be printed and the upper section secures the screen. Ideally, movement should be possible between substrate and screen.

THE PRINCIPLES OF SCREEN PRINTING (click to Animate)

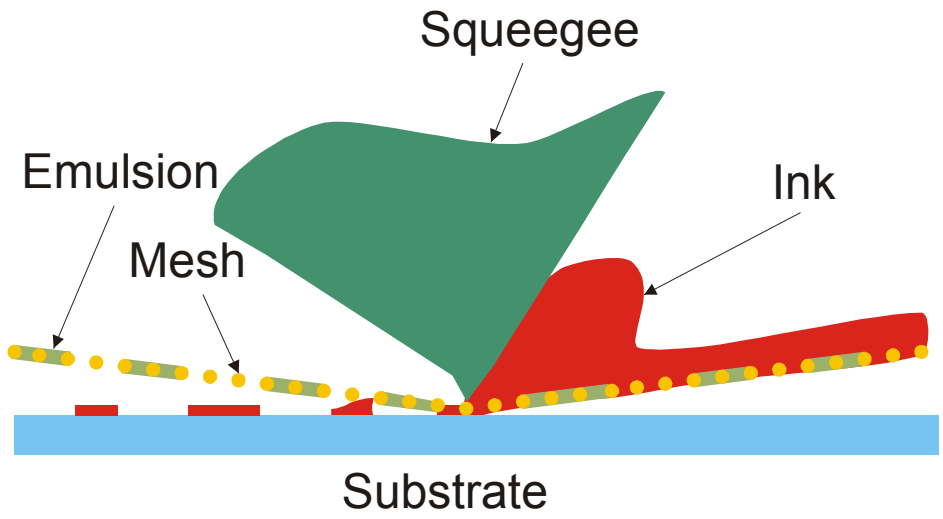
FUNCTION OF THE SQUEEGEE

In conventional screen-printing the squeegee is the engine of the process It carries out two functions. It deflects the stencil and brings it into contact with the substrate. The horizontal movement of the squeegee relative to the stencil causes ink to flow through the mesh in the open areas of the stencil onto substrate.

The squeegee is held at an angle of typically 75 degrees to the horizontal.

During the printing action the squeegee is moved across the stencil, creating a pressure wave in the ink. The pressure wave is caused by the principal force exerted on the ink by the motion of the squeegee and the resistance of the ink to this force. The pressure created in the ink wave causes the ink to move in the direction of the least resistance, principally through the screen openings. The actual point of flow is where the leading edge of the squeegee is in contact with the stencil. This is known as the “Flow Point.”

VIEW OF SQUEEGEE CAUSING INK TO FLOW THROUGH SCREEN AND STENCIL ONTO PRINTED PART



FLOOD COATER OPERATION

For the process to operate efficiently it is necessary to fill the openings in the mesh with ink before the squeegee causes the ink to flow through the mesh. Although not used in every application the flood coater not only charges the mesh but it also helps to stop ink drying in the mesh and effecting print quality. Setting the flood coater is an important aspect of the process. Settings and configurations will vary for different applications.

FACTORS INFLUENCING FLOW OF INK THROUGH THE MESH

Mesh count (Number of threads per linear centimetre), thread diameter and weave (Plain or Twill) is the main determining factor in the amount of ink that will pass through the mesh. This in turn controls the ink deposit. The mesh construction can be considered as a constant however mesh that is worn will produce variations in ink film thickness.

Condition of the ink is the greatest variable. Its stability during the print run is one of the main parameters of which the ink maker has to take account. Uncontrolled addition of solvents or bases during the print run can destabilise the print and create high levels of rejects.

Ambient conditions can have a major effect on the ink. The evaporation of solvents from solvent-based inks when on the press is a recurring problem. Changes in temperature will affect the rate of evaporation and influence the length of time ink will maintain its working consistency on the screen. Even with Ultra Violet (UV) curing inks temperature variation will alter the viscosity of inks and hence their flow. For the screen printer managing these changes is a key skill. Working in a controlled environment will go some way to resolving these issues but consistent high quality printing requires a skill that is very satisfying when acquired.

FACTORS INFLUENCING IMAGE DEFINITION

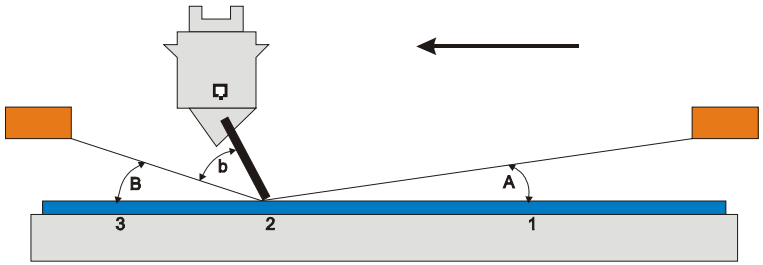
When the stencil comes into contact with the substrate the ideal situation is for a seal to be formed between the bottom of the stencil and the surface of the substrate. This seal should contain the ink within the image area. It will do this if the bottom of the stencil is flat enough to stop ink leaking out and creating an uneven edge. This effect is known as saw-toothing of the image. It also shows itself as dot gain in four-colour process printing. Flatness is an important determinant is the quality of fine lines and half tones. The condition of the ink can also have a considerable effect as if it is too thin it will spread.

The make up of the stencil will affect the thickness of the ink film. How the machine is set will have a considerable affect on print quality. It all adds up to a need for accurate control of all aspects of the process.

FLAT BED PRESS

On a flatbed press, the screen and print table are in a constant fixed position and the squeegee moves through the print stroke from position 1 to position 3. The off-contact distance between the screen and printing table will determine the screen-to-substrate angles both ahead of and behind the squeegee (angles A and B). To aid peeling, a mechanical peel function would lift the screen at the end, creating angle A, and (in theory) hold it constant, but B will still change constantly. With or without a peel function, the angle of the squeegee to the substrate (b) will remain constant throughout the stroke, but continually decrease relative to the mesh.

FLAT BED PRESS OPERATION

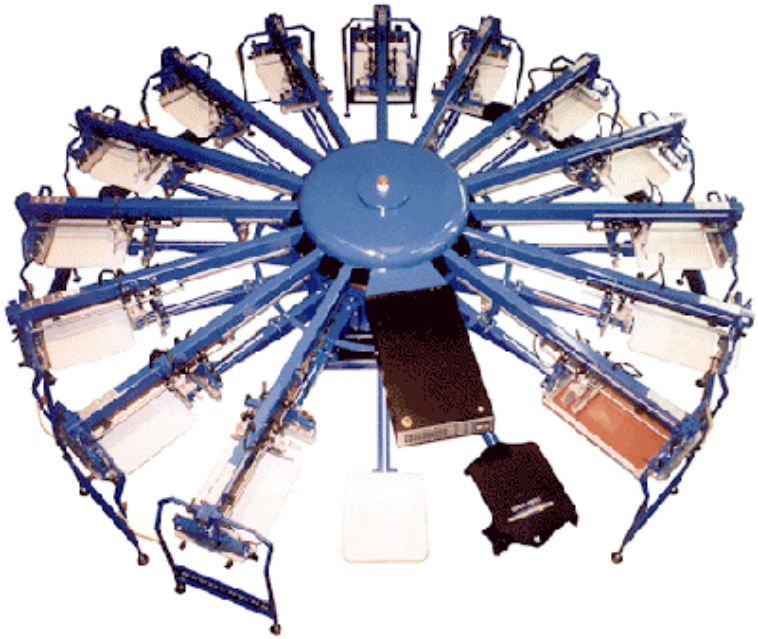


TYPICAL FLAT BED PRESSES

HAND BENCH SCREEN PRINTER
COURTESY OF NATGRAPH LIMITED

SEMI AUTOMATIC FLAT BED SCREEN PRINTER
COURTESY OF HG KIPPAX & SONS LIMITED

ADELCO CAROUSEL TEXTILE PRINTER
COURTESY OF ADELCO LIMITED



4 COLOUR AUTOMATIC FLAT BED SCREEN PRINTER
COURTESY OF REGISTERPRINT LIMITED

CYLINDER PRESS OPERATION

The substrate is held by vacuum on the cylinder, which rotates clockwise. As the cylinder rotates, the screen moves in time to the cylinder while the squeegee stays stationary. The curvature of the cylinder acts to generate much of the peel function by peeling the substrate away from the screen. Off-contact is employed in a cylinder press, but typically is much less than on a flatbed press. This means that angles A and B will stay more constant through the stroke, as will squeegee angle b. In practical terms, this means that the peel and ink-transfer rates will be more even across the length of the print, which can be of great benefit in printing fine-resolution images.

CYLINDER PRESS OPERATION (Click to Animate)

The contact point of the squeegee to the cylinder can occur exactly at the top of the cylinder, which is properly referred to as Top Dead Centre or TDC (also referred to as printing on "the crown").

The typical press will allow the squeegee to be moved forward and backwards from this point (as well as adjusted for basic angle). When it is moved forwards, towards the gripper edge it is known to be (ATDC) after top dead centre. When moved back, it is printing (BTDC) before top dead centre.

When the squeegee is moved in this way, it changes angles A and B and can be carried to the point of smudging the print by pressing the mesh against the curve of the cylinder ahead of or behind the squeegee.

Sharpening the squeegee will reduce its overall height and slightly move the contact point of the blade. Adjustments may have to be made to bring it back to the desired position.

Changing the geometry will modify the flow of ink through the stencil openings. As will adjusting the viscosity of the ink or the speed of the machine.

AUTOMATIC CYLINDER SCREEN PRINTER COURTESY OF TRUMAX LIMITED

CYLINDRICAL SCREEN PRINTING (Click to Animate)

PRINTING USING A CYLINDRICAL SCREEN

This method is used for printing a web of material. Originally used for textiles and carpets where the width of the cylinder (over 2 metres) was required. The system is also used in smaller format for label printing where it can be run at high speed to keep up with other processes in the line. The printing of ceramic tiles is also an important area for this method. The mesh is normally nickel and it is held between two clamping disks at either end. Tension is applied by pulling the disks apart. The technique is ideal for repeat patterns, the size and pitch of these being dependent on the diameter of the cylinder.

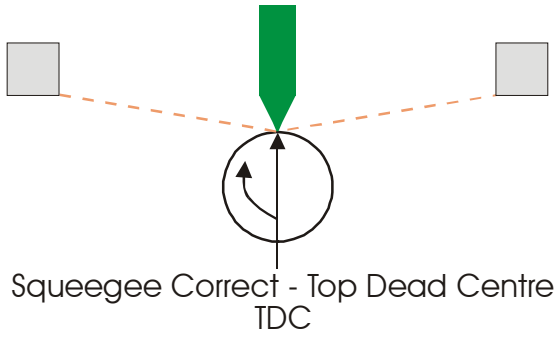
CONTAINER (CYLINDRICAL) SCREEN PRINTING

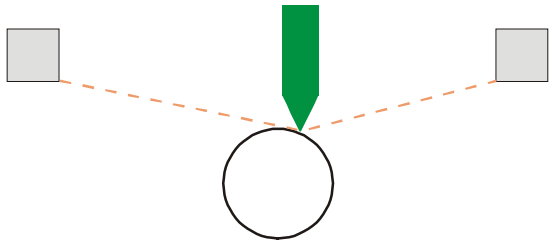
When printing onto containers the principle of operation is similar to that of the cylinder press in that the stencil moves and the squeegee remains stationary (except for the lift and fall). The container/bottle is placed in position under the stencil. Depending on the complexity of the container being printed it is either mechanically driven by a ramp, normally on the base of the container or the combined contact of the stencil and squeegee cause the container to rotate.

There are a number of rules that must be followed, firstly the squeegee must be positioned Top Dead Centre (TDC) of the container. The squeegee edge should be parallel to the container surface and the snap distance as small as possible.

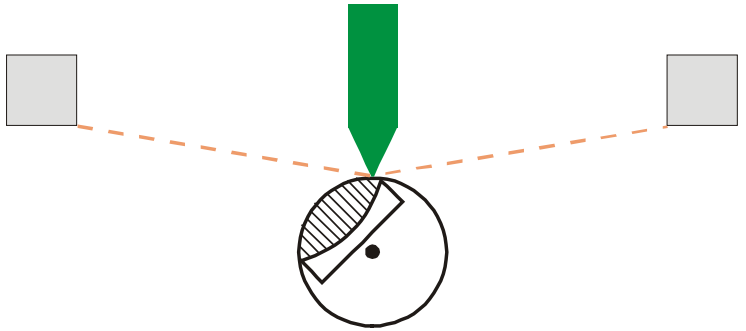
To print an oval container the curvature on it is treated as a section of a much larger cylinder. When it is printed it is rocked about the axis of this larger cylinder.

Round Container





Oval Bottle



Squeegee Position as per Round Bottle
TDC

Printing of conical containers where the angle is slight, up to 3^{O} can normally be printed on a conventional cylindrical printer. Once the angle increases above this then the image on the screen has to be produced in an arc. The container is held in a counterpoint, such that the surface to be printed is horizontal. The squeegee is mounted at TDC and the stencil is moved through the same arc as the artwork. This is a specialised machine, which can be expensive.

CONTAINER SCREEN PRINTER (CYLINDRICAL)
COURTESY OF MASCOPRINT DEVELOPMENTS LIMITED

APPLICATIONS FOR SCREEN PRINTING

It would be possible to run a competition for how many different applications there are for screen-printing and nobody would win because they are increasing day by day.

What makes screen-printing so popular is the ability to lay down a film of a huge range of materials on a vast range of substrates. Everywhere you look are examples of the process and many places that are hidden.

Most people think of posters as the main application of screen printing. This area is known as Graphics, particularly Point of Sale. The market is far more diverse. The chart below shows the breakdown in Western Europe, which is typical of most markets.

In a digital age it is very easy to dismiss screen-printing as a process in decline. Prophets of doom considered that it was in “meltdown”, that digital printing technologies would reign supreme. Exponents of screen-printing have embraced digital technology in all its forms and used it to improve screen-printing and broaden their range of expertise.

Where screen-printing scores is in applications that require consistent application of materials within precise boundaries. Ink is simply one of the materials used as the printing medium in the screen-printing process. If the material can be formed into fine enough particles and dispersed into a fluid it is likely that it can be screen-printed. Common materials that can be printed other than pigmented inks or dyes: Antibiotics, Butter, Carbon, Deodorants, Emulsions, Frit, Glass, Hydrocarbons, Iodine, Juice, Kaolin, Lanolin, Magnetic materials, Nitrocellulose, Oil, Polyurethane, Quince extract, Resins, Sugar, Titanium, Urea, Vinyl, Wax, Xylene, Ylem (Well you try to think of one other than yellow. If you are interested it is used in alchemy, substance from which the elements developed. I will let you have Yolk as in eggs), Zinc.

Applications include: Posters and point of sale displays, gaskets, watch dials, key pads, transfers, electronic circuits, car windscreens, road signs, architectural glass, tableware, nameplates, labels, ceramic tiles, vehicle instrumentation, mouse mats, office equipment, membrane switches, estate agents boards, textiles, fuel cells, pzt, containers, electronic circuitry, playing cards, scratch cards, heating elements, footballs, baseball bats, cricket bats, tennis rackets, golf clubs, clocks, fine art limited editions, laptops, plasma screen televisions. These are just a selection.

From the above lists it is clear that screen-printing is an extremely versatile process that plays an important part in our lives. Without it life would not be as colourful and many of the more exciting technical developments of the 20th and 21st centuries would not have progressed. It was the original printing process in the form of stencilling and will be with us for many years to come.

SCREEN PRINTING MARKET