Screen printing – Part 2

Printing formes and meshes

The various applications of screen printing require a large number of printing formes. The screens are classified into rotary screens and flat screens. Rotary screens are, e.g., used in label printing or in textile printing with repeat motifs. The majority of the printing screens are flat screens. They are used in all fields of screen printing. The dimensions may range from just a few centimetres to several metres. Since screen printing is an indirect printing method, the printing screen must carry a reverse image. For the production of the screen by means of a film and conventional imaging, a right-reading positive film is needed. For direct imaging and direct exposure in a Computer-to-Screen (CTS) process, this intermediate step is not necessary.

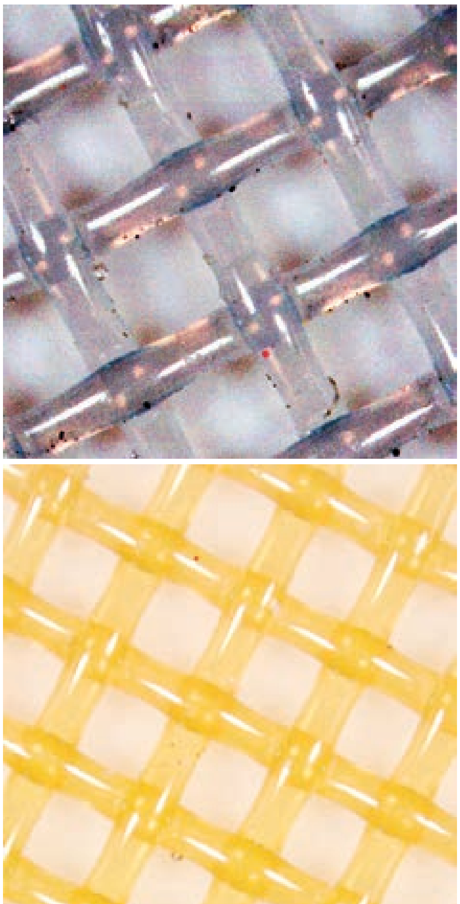
The following description mainly focuses on flat screens. The screen printing forme (i.e., the screen) essentially consists of three components – the frame, the mesh and the stencil (the copying layer). In the early days of screen printing, a frame made of wood with a fine silk cloth stretched over it was used. Silk enabled to produce very fine fabrics with high tear strength. For modern screen printing, the demands on the screen printing forme are much higher. For instance, little warping of the mesh is a prerequisite of a true register in multi-colour printing or high precision circuit board printing. At the same time, the mesh must be flexible enough to ensure sufficient snap-off in printing and clean release of the ink from the mesh. Continuous development work as well as material research has made it possible to satisfy these requirements. The frames and mesh materials used must withstand the consistently high tension forces and feature sufficient resistance to aggressive chemicals and mechanical strain in the printing process. Modern screen printing formes consist of a frame made from aluminium profiles, aluminium cast or a steel frame onto which meshes made of polyester, polyamide or stainless steel are stretched and glued. The frame gives the necessary stability. Most often profiles made of aluminium are used. They feature high stiffness and low own weight. The requested stiffness, deflection and corrosion resistance can be influenced by the choice of the profile width and the profile cross-section. For the frame profiles, there are patented plug and screw systems which enable easy assembly of new frames. Nevertheless, fixed-format, welded frames are the ones that are most commonly used. They can be used several times and are easy to clean and reprocess when regularly maintained.

Before a new mesh is stretched over the frame, the frame must always be checked for damages like tears or deformations. In cases of doubt, damaged frames must be sorted out, since they do not withstand the constant tension forces and cause strong tolerances during printing with far-reaching results for the printing job and the printing technology. If the frame is undamaged, a new tensioning process can be started. The mesh is stretched by means of a pneumatic tensioning system consisting of several tensioning claws that are connected with each other until the necessary tension is reached. The tension is measured and controlled with tensiometers. After a short adjustment phase (relaxation phase), the mesh is tensioned again and finally glued to the frame with a fast drying 2-component adhesive. Once the adhesive is dry, the tensioning clamps are released and the mesh is neatly cut at the outer edges of the frame. Upon completion of the gluing process, the outwards acting tensile forces of the frame ensure a stable state of tension of the mesh. After completion of the tensioning jobs, the screen is marked with the material IDs. The material ID includes specifications as regards thread count, thread diameter and the material the mesh is made of.

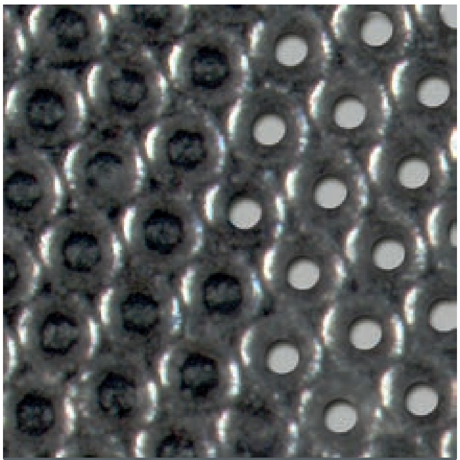
The threads used for weaving are classified as multifilaments and monofilaments. Multifilaments are woven of several twisted strands. These meshes are thicker and less rub-resistant in the printing process than the monofilaments. Monofilaments consist of one single strand and enable to produce extremely fine meshes with very high rub-resistance. Due to the better material properties, overwhelmingly monofilaments made of high modulus plastic fibres are used now.

Rotary screen

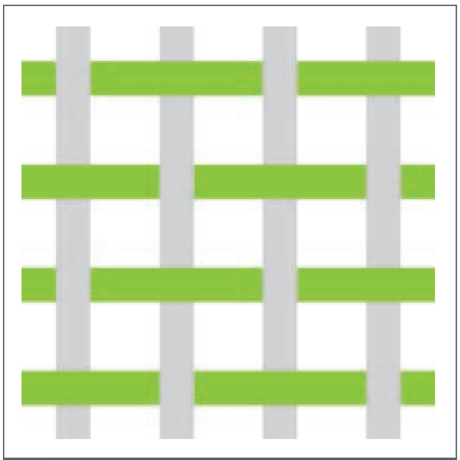
Flat screen



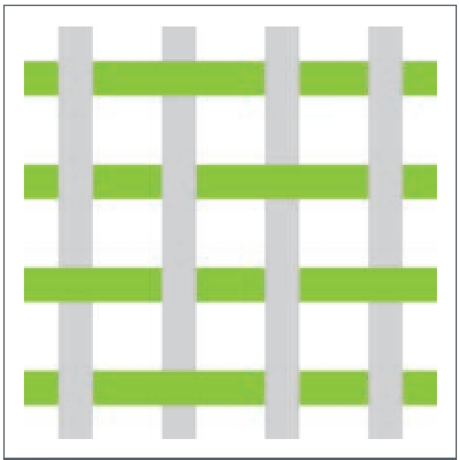
Modern meshes of molafilaments



Details of a rotary screen



Plain weave



Twill weave

The most frequently used mesh material is polyester. Polyester features high elongation and tensile strength as well as resistance against numerous chemical compounds. Polyester meshes are preferably used in textile printing, in finishing processes with offset printed products or packaging materials as well as in printing on plastic materials. The material shows low elongation tolerances in multi-colour printing. The screen printer must ensure register precision by selecting the correct contact pressure during the squeegeeing process. When aggressive printing chemicals and strongly abrasive materials like ceramics are used, polyamide is a good choice for the mesh. Polyamide features similar characteristics as polyester and additionally offers resistance to alkaline media. The higher elasticity of the mesh compared to polyester enables to print on slightly uneven bodies. For the printing of very fine structures, as e.g., in the production of circuit boards, meshes made of stainless steel are used. With stainless steel, meshes with up to 200 wires/cm can be produced. Partly also as a collage of polyester (zone at the edges) and stainless steel (printing zone). Stainless steel meshes feature only limited elongation and are prone to plastic deformation and breakages and thus the destruction of the mesh when under excessive stress.

For the production of the mesh, two kinds of weave are used, i.e. plain weave and twill weave. Plain weave (in short: PW) is the simplest form of weaving. The weft and warp threads are interwoven 1:1. The result is a thick and stable fabric. For twill weaving (in short: TW), the interweaving of weft and warp threads changes. There are weaves with 2:1, 2:2 or 3:3 ratios. The interweaving specification refers to the weft thread. In the 2:1 ratio, for instance, the weft thread crosses, in turn, one and then two warp threads. The next weft thread is then moved by one warp thread so that a diagonal pattern is created. After the weaving process, further enhancements of the mesh through calendering or inking may be added. Treatment in a calender (roller mill) flattens the mesh, i.e. its thickness is reduced. This treatment minimizes the ink volume that can be transferred to the mesh. The cross-section of the thread is squeezed where the weft and warp threads cross, as a result the mesh aperture gets smaller. The mesh is dyed yellow in order to reduce the undercutting effect during exposure. The blue light portion contained in UV light is absorbed by the yellow mesh so that unwanted scattered light is reduced.

Looking at the mesh specifications, the screen printer can deduce important characteristics like printing behaviour, open area (Ao) and theoretical ink deposit (Vth). For example, the designation PET 48-55Y-PW gives the following information:

PET = Polyester, 48 = thread count per cm,
55 = thread diameter in µm, Y = yellow dyed mesh and PW = plain weave

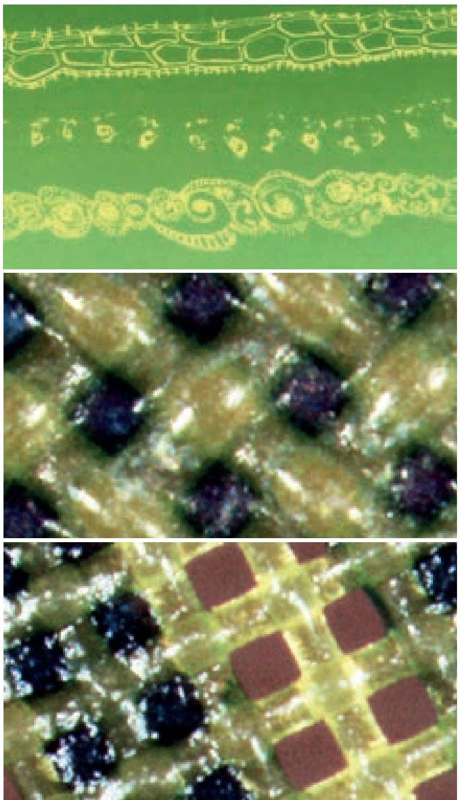
The mesh open area is the ratio between the area covered by the thread and the area that is open. The open mesh is dependent on the aperture size/mesh opening (w). The sum of the aperture size and the thread diameter (d) gives the mesh thickness (t). In combination with the mesh thickness, the theoretical ink deposit can be calculated. The applicable mathematical correlations are as follows:

1cm = 10.000µm

w = (10.000µm – (d x thread count)) / thread count

$t = w + d$ Ao= $w^2 : t^2$ x 100% Vth = Ao x D

These calculations are only indicative of the actual values, since the calculation is based on the unwoven thread with a round cross-section. At least with a calendered mesh, the exact definition can only be achieved with geometrical measuring processes. As a rule, the mesh manufacturer can be asked for the key data. With the right mesh selection, the screen printer defines the thickness of the ink layer, the printable fineness of lines and resolutions as well as the maximum particle size of the screen printing ink. If, for example, a high ink film thickness with little details is required, a rough mesh with a small number of threads per cm and a higher thread diameter will be chosen. Fine screen printing, however, can only be produced with a high number of threads per cm and very thin threads. In general, the highest resolution is achieved with fabrics with a mesh size that is larger than the thread diameter. The interdependencies explained above show that the printing forme and explicitly the choice of fabric during job preparation in screen printing are of absolutely crucial importance. One wrong decision will quickly cause unsurpassable problems in printing and may require the job to be stopped.



On the top: Fabric with copying layer ready for print.
Center and bottom: Details of the copying layer on the mesh.

Ronald Weidel (azp Chemnitz)