Lower numbers are always fancied when talking about age and price tags. We like our laptops, waist lines, and televisions when they’re thinner. It is no different when it comes to mesh-thread diameter.

Filament diameter (thread or wire), in its intimate relationship with mesh count, dictates the mesh parameters that most define our print results. The association of filament diameter and mesh count directly determines mesh opening size, open area porosity, mesh thickness, and a handful of other significant mesh parameters. In turn, the combination of mesh thickness and open area at tension provide the dominant influence on the thickness of our printed wet ink film.

Influence of thread diameter on mesh parameters
When mesh count remains unchanged, choosing a smaller filament diameter opens up the mesh and renders it much less obstructive to ink flow. This is readily apparent in the representative illustration in Figure 1 of 380-thread/in., low-elongation polyester mesh, incorporating three different thread diameters (27, 31, and 34 microns Ø).

The increased open area of mesh types with reduced thread diameter at similar mesh count equates to less filament surface area within the print cavity. As ink passes through a screen’s print cavities, it is in direct contact with the threads. By reducing the thread surface area, mesh will release easier at the moment of ink transfer.

Smaller diameter thread at the same mesh count creates higher open area by increasing the size of the mesh apertures. Larger mesh openings allow for easier transfer of higher viscosity inks, or inks that have relatively larger particle size or high solids content, often desired to achieve special effects and to help give the color some visual pop.

Additionally, filament diameter size has the most influence on mesh thickness. When the diameter is reduced, overall mesh thickness becomes thinner. Larger thread diameter increases mesh thickness.

As we can see in the overhead view in the top portion of Figure 2 showing similar mesh counts, the smallest filament diameter indeed provides the largest mesh aperture size, providing greater open area. The cross-sectional view of the mesh weaves shown in the lower half of Figure 2 depicts the reduction in mesh thickness resulting from thinner thread diameter. The red blocks represent the open columns in the mesh through which the ink must transfer. The taller, chimney-like column on the right is a result of a thicker, more closed mesh, due directly to a larger diameter at similar mesh count. The increased thread-surface area, taller mesh, and smaller opening size make for more difficult ink flow and transfer from screen to substrate.

Influence of thread diameter on ink profile
Mesh thickness, as a direct result of thread diameter, can have an impact on the surface profile of the printed ink film. In rheological terms, most printing inks are formulated to be pseudoplastic or shear-thinning. When a shear stress is applied to a pseudoplastic ink (stirring, or spreading with a squeegee, for example), the viscosity of that ink drops noticeably, making the ink more fluid during the period the shear is applied. This rheological property is used to assist the ink to flow in and out of the screen mesh easier during the print stroke. However, we all like to hold sharp detail in our prints, so we need this decrease in ink viscosity to stop, and in fact reverse course, when the print stroke and ink transfer are complete. Fortunately, part of the pseudoplastic materials formulation is that they return to their at-rest viscosity once
application of shear stress is ceased. The viscosity reduction of most printing inks during the print stroke can vary based on a number of factors, including the specific ink formulation, and the amount of shear stress applied to the ink during the print stroke. Some materials shear thin more than others. Some inks may shear thin very little or not at all. Depending on the how much the printed ink flows, some inks are more prone to leaving evidence of printing in the way of mesh marks or imprints of the mesh filaments in the surface profile of the ink.

As depicted in Figure 3, mesh with larger diameter thread size is more likely to leave a rougher surface topography on printed ink film compared to mesh with thinner thread diameter. Ink shear (and viscosity drop) ceases once the ink is cut by the squeegee into the mesh apertures. While the printed ink begins its recovery back to rest viscosity, any bigger imprints left by larger filament sizes may not flow out completely, remaining in the ink profile.

**Influence of thread diameter on stencil quality**
The taller weave of mesh with larger diameter and lower open area can also affect several important characteristics of the stencil coating. The taller profile of mesh having larger thread diameter makes it more difficult to maintain a smooth stencil profile (lower Rz value) when coating with direct emulsion. As the wet emulsion layer dries into the mesh, the resulting surface topography of the coating is greatly influenced by the mesh profile underneath. The dried profile of the stencil coating takes on that of the mesh which supports it from below.

Figure 4 shows two stainless-steel screen types, one with 25-micron wire diameter and the other having a wire diameter of 16 microns. The top set of photos show the emulsion stencil topography on both mesh types when the direct emulsion stencil thickness is
just 7 microns. The lower set of photos contained in Figure 4 show the identical two mesh types when the EOM (emulsion over mesh) is increased to 18 microns. The mesh profile underneath influences the coating surface profile particularly when the coating EOM is thin, but is more apparent when the mesh is thicker as a result of larger diameter size.

As diameter increases and open area becomes more closed, the wire weave displays a taller profile. When wire diameter decreases, open area increases and the weave profile is lower and smoother. Because stainless-steel mesh is shiny and reflective, the lower weave profile of mesh having smaller wire diameter and increased open area can in many instances be more advantageous when screen imaging.

Figure 5 displays two stainless-steel wire screens, both coated and imaged identically with the exact same stencil system, artwork, equipment and procedures. The 18-micron wire mesh shown in Figure 5 has 42% open area, while the 16-micron wire mesh has 60% open area. The weave profile of the smaller diameter/higher open area mesh is lower, while the larger diameter/lower open area mesh has a higher weave profile. This higher weave profile of the larger diameter wire size resulted in irregularities along the edge of the screen image due to reflection of UV light off the taller wire profile during screen exposure. This phenomenon is much less apparent with smaller wire diameter, higher open area wire cloth.

**Filament diameter vs. mesh tension**

We know when mesh thread diameter becomes smaller while maintaining similar mesh count, the open area of that same mesh increases. Higher open area percentage advises that there is lower mesh content within the mesh area. When the amount of mesh content within a fixed area is reduced, the tension capability of that mesh type is also reduced when all else remains equal.

Historically, lower tension capability was one of the main drawbacks to smaller diameter/higher open area mesh types. Screen tension is vital in achieving proper ink transfer in the screen-printing process. Ink transfer in screen printing is different from most other printing processes. Offset, gravure, and letterpress printing all carry the ink on the outer surface of what comprises the printing plate component of those respective imaging methods. These printing methods involve intimate contact between the printing plate and the substrate. The ink transfer doesn’t actually occur until the moment the printing plate and the substrate separate from each other. Inkjet printing does not use direct contact with the substrate, instead incorporating a print head to propel ink droplets onto the substrate surface.

The screen is the printing plate of the screen-printing process. The ink is applied to the surface of the screen furthest from the substrate and must then pass through patterned openings in the printing plate in order to make contact in those areas with the substrate.

While recognizing that the ink transfer occurs at the moment of separation of the screen from the substrate, we also must contend with the common rheological properties of most printing inks to shear thin when squeegee motion is applied, and recover to rest viscosity when the shear stress is ceased. This suggests that it is best to have that separation of screen from substrate occur before the ink has completely returned to its higher idle viscosity. Considering, it would be most desirable to have the screen and substrate separate progressively and immediately behind the moving squeegee, rather than waiting for the entire print stroke to complete and then attempting to separate the two. At that point, the ink viscosity is increasing and it will be difficult to get the mesh to cleanly release from the print without leaving some print flaws such as voids and mesh marks.
screen to separate and lift up from the substrate directly behind the traveling squeegee line, much like peeling a piece of tape up from a table top. This relatively immediate screen lift or screen peel, allows the mesh to be removed from the print deposit before the ink can completely return to higher rest viscosity. The small amount of elastic property retained in the mesh permits this repetitive deflection action for continued use.

For separation of screen and substrate to occur, the counter force provided by mesh tension and off-contact gap must exceed the hold down force provided by ink tack. It is more desirable to increase counter force (when necessary) by using higher mesh tension rather than increasing the off-contact gap. Deflecting the screen into contact with the substrate from a higher distance has a greater chance of initiating dimensional distortion, and likely creating image registration concerns.

Higher screen tension creates desirable screen peel activity while maintaining a lower off-contact distance to minimize image distortion.

**Stronger, small filaments**

The smaller diameters associated with advanced filament mesh types provide for increased open area percentages which aid in easier ink passage. The mesh thickness is noticeably thinner on these advanced mesh types as well, helping to maintain smoother ink film and stencil surface profiles. The resulting estimated ink-film thickness remains basically unchanged to ensure opacity and color aren’t substantially altered.

The most significant parameter is tension value (Figure 6). It is here we can recognize the biggest benefit of these smaller, higher strength filaments. The tension capability of these new filament mesh types meets or exceeds that of its standard mesh counterparts, even though their diameter size is significantly smaller. These higher modulus filaments create a more stable mesh, helping to maintain dimensional accuracy while the higher tension capability combined with small diameter size and increase open area allow for better ink transfer. Thin is in, and you no longer need to settle for lower screen tension.

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