THE PERFECT MESH

Steven Abbott offers some insights into what's going wrong with our current meshes and how they might be made a little better

THE POINT OF THIS ARTICLE IS TO STEP BACK FROM THE DAY-TO-DAY REALITIES OF MESH TO RECONSIDER WHAT IT'S SUPPOSED TO BE DOING AND THEREFORE LOOK AT OUR CURRENT MESHES WITH FRESH EYES TO SEE IF THEY CAN IN ANY WAY BE IMPROVED FOR OUR BENEFIT.

If everyone understood what current meshes are doing, then the need for this article would be less. Unfortunately there are many unhelpful myths out there in the marketplace and, sadly, these myths are doing real harm to real printers' real incomes. I make no apologies for speaking out against these myths, because any myth that causes someone from the screen print fraternity to lose their job is a myth too many.

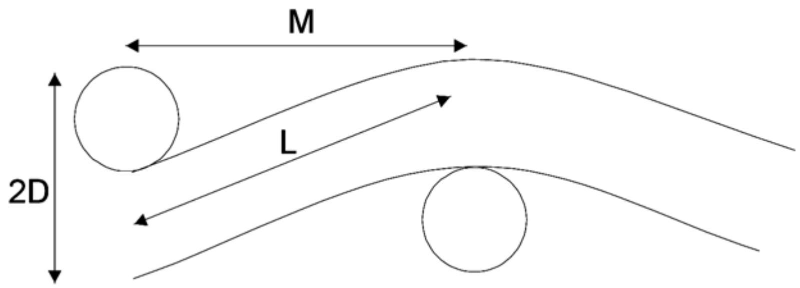
THE MESH DOES THE METERING

The myth that the ink deposit depends on the squeegee or the stencil has caused more job losses than any other. The squeegee is simply there to fill the mesh and scrape off any excess ink. In conventional screen printing, the stencil is there mostly to define the shape of the print. It's the mesh which controls the thickness of the ink deposit. Those who like to live dangerously (and unprofitably) can have a modest effect on ink deposit by fiddling with the squeegee, and of course if you need an extra few µm of ink in a small open area then you can control this with the stencil thickness, but overwhelmingly, it's the mesh that does the metering.

So the first thing we need to know about the perfect mesh is how much ink is in it just before the mesh comes out of the ink and away from the substrate – the 'ink-in-the-mesh-at-the-start'. This is just a matter of geometry. For engineered meshes such as those grown in nickel, the manufacturers do this calculation accurately. One of the scandals of the screen industry, in my opinion, is that woven mesh manufacturers don't do the correct calculations; instead they multiply an 'open area' by the mesh thickness and quote that value. There is no justification for this and the results are often misleading. The real formula is well-known and all woven mesh manufacturers should be quoting this value, but they don't.

MESH GEOMETRY

One fact that seems to surprise most printers is that the volume of ink in the mesh just before it rises from the substrate is not the volume of ink that is printed. Just as honey stays on a spoon as it's lifted from the honey jar, so the mesh remains covered with a thin layer of ink. Thus the amount of ink printed is ink-in-the-mesh-at-the-start minus ink-on-the-mesh-at-the-end.



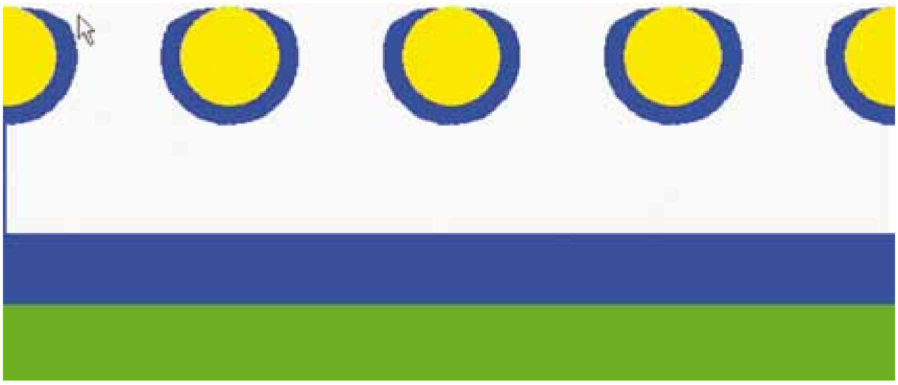
The mesh geometry

$$TIV = 2D - \pi\frac{D^2\sqrt{1+TPM^2D^2}}{2M} = 2D - \pi\frac{D^2TPM\sqrt{1+TPM^2D^2}}{2}$$

The (simplified) formula for Theoretical Ink Volume or 'Ink-in-the-mesh-at-the-start'

There is no simple way to calculate the second value, so it has to be measured. It's not hard to do and it is another scandal that mesh and ink manufacturers don't routinely do this so their customers know right from the start how much ink gets printed. It's not as if they don't have the technical capability, it's just because the mythology of screen printing gets in the way of them providing customers with this simple, vital information. If you need a rule of thumb, then choose 30% as the ink remaining on the mesh. For those who thought that no significant amount of ink remains on the mesh this figure is quite a shock, but anyone who doubts it can check their own ink on their own mesh and reach the same conclusion.


Ink in the mesh at the start


Ink deposit = Ink-in-the-mesh-at-the-start minus Ink-on-the-mesh-at-the-end

There was a fashionable myth some years ago that some meshes provided 'better ink transfer' thanks to a 'special surface coating'. The simple laws of physics show that no surface coating can have any effect on the

The ink is thicker at the edge because of the EOM, but normal in the middle …

… unless you have a very strong mesh under high tension

amount of ink-in-the-mesh-at-the-start (that's just geometry) nor on ink-on-the-mesh-at-the-end (other than, perhaps, Teflon) because the surface of the mesh after the first print is, well, just ink.

The so-called no-slip condition of fluid flow guarantees that at least a monolayer of ink will always remain on the mesh after contact, so the mesh surface can have no effect whatsoever on the subsequent ink flow. And in reality the remaining ink is a few µm – even less chance for the mesh surface to have an effect on the subsequent print.

But we know that two different versions of 'the same' mesh do deliver different quantities of ink. This is nothing to do with special surface treatment, sometimes it's to do with the precise geometries of the two meshes. Depending on how squashed (or calendared) the two meshes are, the ink-in-the-mesh-at-the-start will be slightly different. That's one reason (amongst many) why it's a scandal that mesh manufacturers don't provide this figure. If you don't know in advance how much ink is in there then your second task – knowing how much remains – is even harder.

BASIC INK DEPOSIT

So far I've been confident in what I've written because the physics is unarguable, but I have to admit to not fully knowing the formulae for how much ink remains on the mesh at the end, hence my rule of thumb above. This really does depend on the details of the mesh. I'm certain, for example, that the mesh knuckles play a large part in controlling this factor, but I've not had the time or energy to work out why Mesh A differs in detail from Mesh B.

Why don't the mesh manufacturers do this as a matter of routine? What I can say with some confidence is that the amount of ink remaining depends very little on the ink or printing conditions. High or low viscosity and high or low speed printing both seem to have only a small effect. You don't need to take my word for it, test it yourself: take a hand bench and slowly print an ink through a stencil, then put that same stencil onto your most advanced press and repeat. You will find almost no difference in the amount printed. This is common knowledge but because of the mythology of complex controls on expensive presses, this basic fact is ignored.

Thin mesh good, thick mesh bad for printing fine lines

So, what is the perfect mesh in terms of basic ink deposit? It is one where you know beforehand (preferably with data provided by the mesh manufacturer) the two terms, ink before and ink after, and where the difference (i.e. the ink left on the substrate) is exactly the deposit you require. If you need an extra micron or two, by all means add a few microns of EOM to your stencil – unless, of course, you are printing large open areas where the stencil has no effect whatsoever.

If you have a very high tension and a very rigid mesh then the squeegee won't force the mesh into contact with the substrate, instead it will remain suspended above the mesh by whatever your EOM happens to be. For some people this is a definition of perfection, and the liquid crystal meshes are outstanding at doing this.

But there's a downside to all that lengthwise strength for the liquid crystal polymer – it has little strength across the fibre. So when it is woven it is easily squashed and produces a fat fibre, which is something you generally don't want. These fat fibres also invalidate the simplified Theoretical Ink Volume which assumes circular fibres. A more appropriate formula is available for these highly elliptical meshes.

THIN IS GOOD

Screen printing would be even better if it weren't for the screen getting in the way. The only good mesh for printing is a thin mesh – when viewed from the top. The perfect mesh would be just a few microns wide yet with a height able to deliver the required quantity of ink. Only nickel meshes can aspire to this ideal. Thin woven meshes are, for obvious reasons, not very deep. Stainless fibres don't get squashed much on weaving, so they are the best practical combination of thin and deep.

Because thin fibres are necessarily weaker than thick ones, for stability of the screen the only way to have enough fibre to resist the stretching forces is to have more threads per unit length. Because fibre area goes as the square of the diameter and linearly with thread count, it's not obvious which is the best trade-off of maximum strength versus minimum mesh getting in the way. It would have been helpful if mesh suppliers gave a figure in their data sheets recording the amount of fibre per unit length but, alas, they don't.

STABILITY UNDER TENSION

The perfect mesh will not creep (relax) under tension, even the reasonably high tensions that good screen printers use. With low creep, tensions remain stable and images remain with perfect registration. There are two aspects to the creep and these are not sufficiently disentangled for users to understand and control.

The first aspect is the properties of the fibres under stress. For a polymer such as polyester, the individual polymer chains can gradually straighten out and slip past each other. For stainless, the grains can slip and elongate. For the liquid crystal polymers, the polymer chains are so straight to start with that there is not much that can change under stress, so the creep is particularly low.

The second aspect is what happens at the knuckles of the mesh. To a certain extent, the fibres are locked against each other when they get bent at the knuckles. However, with vibrations, stresses from the squeegee and, even, lubrication by solvents / inks, the knuckles can slip past each other, resulting in creep.

It would be ideal if mesh providers told us how much creep comes from their fibres (they could provide this information from experiments on unwoven fibres) and how much comes from the knuckles, which in turn depends on how well the mesh has been woven, how much it's been calendared and how solvents / inks can interact with the mesh surface to encourage slippage at the knuckles. It's deeply unfortunate that such creep-related data is not part of the data sheet of all reputable mesh suppliers.

There's one other aspect of tension stability that can prove mysterious if you're not alert to it. Polyester fibre expands by about 15 μm/metre for every 1% increase in relative humidity. A large change in humidity can result in a surprisingly large dip in tension. So another definition of perfection (which stainless achieves) is an absence of expansion from absorption of moisture or solvents.

DOWN WITH KNUCKLES

Knuckles are bad for at least three reasons: firstly they allow creep, secondly they contribute strongly to mesh marking (we know this because the patterns of mesh marking are highly variable and often correlate with alternate knuckles) and thirdly, they are places for old bits of stencil and ink to accumulate and cause image ghosting and uneven mesh marking.

If any mesh manufacturer could come up with a 'knuckle treatment' which reduced creep, made each knuckle identical and filled up the little spaces where junk gets trapped, they would be much closer to having the perfect mesh. Of course, the nickel meshes that are without knuckles are a shining example of the good things that happen when knuckles don't exist at all.

I won't name any names, but one mesh manufacturer caused a lot of problems in the field by shipping mesh which had lumps of their surface treatment chemicals trapped in the knuckles. It was very difficult to spot these lumps and correlate them with the problems they caused. This once again emphasises the fact that mesh manufacturers should really attend to the fine details of the knuckles if they want happy customers.

THE CURSE OF SCATTERING

As printers go to finer lines / dots, the light scattered from the meshes during exposure is a serious problem. The stencil-maker has to choose between under-exposing to maintain resolution but with compromised stencil performance, or over-exposing and losing resolution but getting great stencil performance.

If any polyester mesh manufacturer could source fibres without scattering particles in them, then the need for yellow mesh to help reduce over-exposure would disappear. 'Pure PET' fibres which were crystal clear would be a huge improvement on the current scattering fibres because the yellow dies can't fully quell the scattering.

The stainless mesh suppliers have a different problem. By definition stainless is stainless, so it's hard to create blackened fibres which give a wonderful improvement in exposure performance. It's hard, but not impossible. It is again deeply unfortunate that blackened stainless is not offered as a matter of routine for those doing fine-line printing on stainless.

ADHESION

The fashion some years ago for PET fabrics that gave 'better ink transfer characteristics' was a waste of precious development resource; none of these treatments could possibly help with 'ink transfer'. It would have been far better if the work had gone into treatments that helped with the knuckle issues or treatments for helping mesh adhesion.

Happily, one of the up-sides of some of these treatments is that they genuinely helped get good stencil adhesion. This in turn made it easier for suppliers of emulsions and capillary films to fine-tune their products for performance in other areas such as resolution or print life. It's harder to do this fine-tuning if you have to keep checking for basic adhesion.

THE RIGHT COUNT

The perfect mesh has a known thread count that's even across the width of the screen, is equal in both directions and is the same from month to month, from year to year. I'm not one who thinks that super-high accuracy of thread count is very important; it doesn't, for example, help much with moiré – at best it hides a moiré when the smart thing to do is to change to a different print resolution or different mesh count to avoid the mathematical certainty of moiré. I think that knuckle evenness (not something I've heard many people talk about) is far more important than perfect thread count (which is often portrayed as being super-important).

I've been pretty hard on the mesh manufacturers in this article, but is it their fault that we are provided with bogus 'ink volume' numbers, that we don't have data for ink-on-the-mesh-at-the-end, that we don't have 'amount of fibre per unit width' data, that we don't have good creep data, that knuckles are so unsatisfactory, that we don't have clear PET or blackened stainless and that myths of 'better ink transfer' have wasted resource?

To a certain extent the answer is yes, but we, the customers, need to take more of the blame. The science of what makes a perfect mesh is easy to understand and we could have told our suppliers that unless they raised their game, we'd shift our purchases to their competitors. But we didn't do that; we buried our heads in the sands of sloppy thinking and we allowed myths to haunt this industry for decades. So we have the meshes we deserve.

Once we agree to share the blame, the way forward is easy. It's worth reminding ourselves that what we get when we buy a mesh is pretty amazing: all those tiny threads all perfectly woven, metre by metre, year after year. Yes, these meshes are pretty good under the circumstances – but why should we accept 'pretty good'? We can't get perfection, but by choosing to spend our precious resources with those mesh manufacturers who in turn spend their R&D money on activities that give us what we need, then although we'll never reach perfection, at least we'll get closer to it. sp

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