Effect of press parameters and ink viscosity on ink separation mechanisms in screen printing

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A specially designed screen-printing visualisation rig has been developed for ink and process evaluation, which has been used alongside traditional methods such as shear and extensional rheometry. This has been used to provide validation to existing theories of ink transfer mechanisms, as illustrated in Figure 1. Providing sufficient experimental evidence to identify key transfer mechanisms and provide validation for the theory suggested by Messerschmitt (1). Where the four stages of ink deposition, consisting of adhesion, extension, flow and separation were identified. The screen-printing visualiser (SPV) can also be used to assess quantifiable changes in the ink separation mechanism with changes in press parameters and ink rheology. In the case of press parameters, when snap off distance had significant effects on the adhesion to extension stages, for the commercial carbon ink assessed. Reductions in snap distance led to shallower angles between the mesh and substrate. This led to notable increases in the adhesion to extension stages as at these lower angles. Sufficient shear flow for separating the ink was not achieved until a greater distance behind the squeegee than with greater snap distances. When print speed was increased, the filaments forming during the flow to separation stages also showing changes in the necking profile from that typical of a power law fluid to a weakly elastic fluid, as the ink behaved in a more elastic manner at higher speeds due to its viscoelastic profile. Quantifiable changes in the mechanism were also observed when the carbon concentration of the ink was reduced by increasing the solvent content, leading to a gradual reduction in viscosity and elasticity. Typically, less viscous inks containing lower concentrations of carbon produced a clean separation after the extension stage. While inks containing higher carbon, concentrations produced filaments during separation. Inks producing more filaments during separation were found to deposit more ink. In addition to this, further investigations on the SPV could be conducted to assess the effect of ink rheology on other functional inks as well as graphics inks, the effect of using different meshes and substrates with different surface energies. These results could be used to develop boundary conditions for computational models and predictive methods.

References

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Figure 2. Schematic diagram of the screen-printing visualisation (SPV) rig, with a zoomed in schematic diagram of a cross section through the screen printer and a zoom in showing a labelled high-speed image and diagram quantifying the separation zones.