Direct Gravure Roll Coating – Towards a Predictive Tool

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Direct gravure coating is frequently used for laying down high quality thin coat film thicknesses at speeds of up to 500 m/min. It is one coating technology that can tolerate a range of physical properties of the fluid and, due to the nature of the gravure roll providing a pre-metering of the fluid, will give a film thickness that is relatively insensitive to variations within the process. However this also means that the correct choice of the gravure roll at the outset is important if the target wet-thickness is to be achieved. It is on this wet-thickness that both the formulation of the coating and the specification of the drier is related. Consequently understanding the process at a fundamental level, and having an understanding of the parameters that affect the film-thickness is important to coating practitioners.

A typical arrangement of a gravure coater is shown in figure 1a. The key difference between 'gravure roll coating' and 'smooth roll coating' is that, for the former, the roll is patterned (either mechanically, chemically or ablated with a laser) with a series of regular engravings, either continuously (e.g. trihelical) or discretely (e.g. quadrangular, laser engraved ceramic) across the roll surface – see figure 1b. As the gravure roll rotates through the bath of fluid (or some proprietary chamber) an excess of fluid is picked onto the roll surface and the doctor blade removes the excess fluid above that required to fill the cells.

Within the nip region, where the web is wrapped around the roll by a few degrees, fluid is transferred out of the engravings onto the moving web. In the commonly used reverse mode, the web and roll pass through this coating nip in opposite directions. The fraction of fluid removed from the cell is termed the pick-out ratio, and this is a common measure to gauge the efficiency of the transfer.

This work will focus on the modelling framework that has been established to relate the controlling parameters (cell shape and size, web and roll speeds, wrap angle and tension and fluid properties) to the coated film thickness. The model uses a multi-scale approach at two scales – the large scale captures the global characteristics of the coating bead, whilst the small scale captures the flow within the cells. Computational fluid dynamic simulations are used to solve the flow on the small scale (figure 2) which is then mapped onto the larger scale. Preliminary results will be shown showing the general trends of pickout behaviour, both experimentally and computationally.

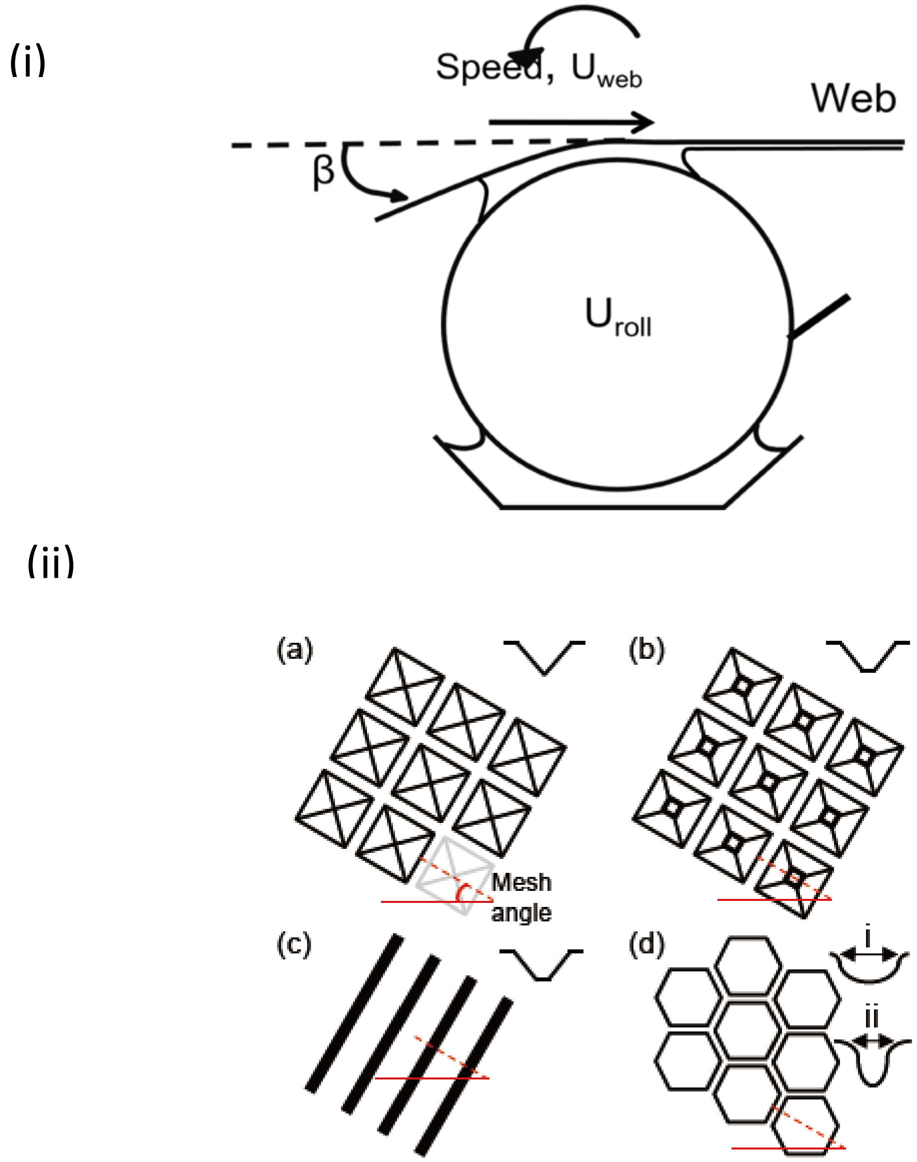

Figure 1 (i) Cross-sectional schematic showing a reverse mode direct gravure roll coater. (ii) typical gravure cells (a) pyramidal (b) quadrangular (c) trihelical (d) laser engraved ceramic

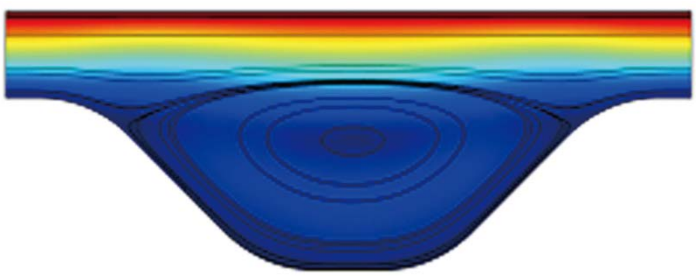

Figure 2: cross-section through a gravure cell showing the flow structure.