REVERSE ROLL COATING: MODELLING OF HIGH-SPEED DEFECT-FREE COATINGS

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Roll coating is an extremely versatile industrial process that requires highly skilled operation to maintain consistency of the coated product. The process occurs widely and often involves coating one side of a substrate (web, sheet) with a fluid formulation, as it passes between co-rotating cylindrical rollers (reverse roll mode). Presently, there is a major push towards using new material products and raising coating line-speeds, for increased efficiency (energy conservation) and productivity, yet requirements of controlled film weight and freedom from defects must be maintained. This study has sought to address these issues by developing an effective predictive toolset for use in the development of high-performance coatings capable of consistent application at high speeds. Findings are applicable across a wide range of coating sectors in optimisation of coating performance, which targets adaptive/intelligent process control.

There are three distinct aspects of the process investigated: flow in the nip-region, the metering region and the substrate film flow before curing (onset of beading). Novel time-stepping/finite element methods are deployed to model this free-surface problem that involves the transfer of a coating fluid from a roller to a substrate (of prescribed wet-film thickness), with a free meniscus in the applicator nip. This procedure is used in conjunction with a set of constitutive equations capable of describing the relevant fluid-film rheology in appropriate detail (shear-thinning, tension-thinning/thickening, elasticity). An additional dimension is also taken into account, that of deformation of rubber elastomer roll covers (via elasto-hydrodymamics). This offers fresh insight on the process with respect to nip-flow behaviour, and allows for the possibility of both positive and negative nip-gaps to be analysed.

The roll coating parameters are subdivided into three distinct groups: (*i*) the operating conditions (roll-speeds and gap-size); (*ii*) fluid-coating properties; and (*iii*) roll-cover properties. Then, the effects of parameter variation on the process is analysed, as a result of film rheology applied, whilst identifying the onset of instabilities. The influence of yield stress levels and degree of surface tension on resultant coatings is also investigated to elucidate the stimulation or suppression of edge-beads on the substrate perimeter.