EUROPEAN COATING SYMPOSIUM 2007, PARIS 12-14 Sept 2007, PARIS

Dynamic Wetting Failure in Air & other Gases under Reduced Pressures

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In the practical context of coating operations, air entrainment is wholly undesirable as it limits processing speeds, hence productivity and if unnoticed will lead to defective un-saleable films. Clearly, understanding this phenomenon and perhaps postponing its occurrence to higher speeds by manipulating the flow and substrate conditions is of huge industrial interest. Since the original work of Ablett (1923) and Deryagin and Levi (1959), many studies have been carried out to correlate the critical speed V_{ae} at which dynamic wetting failure occurs with the physical properties of the coating liquid but except for the recent work of Benkreira et al (2006), no studies has been carried out to assess the effect of the surrounding air or gas. Inevitably, the theories that have been developed do not capture all the physics of the situations (Blake and Haynes, 1969; Cox, 1986; Teletzke *et al*., 1988; Miyamoto, 1991; Blake, 1993; Shikhmurzaev[1], 1993, 1997). Our initial work found for example that the pressure (hence viscosity) of the air is *very important* which suggests that air entrainment is not only on a molecular scale event but that hydrodynamic effects play an important role. Clearly, despite all the progress made in understanding dynamic wetting failure and the established fact that the formation of the triangular structures at the contact line is a prerequisite for air entrainment, we still do not have an accepted full proof theory of dynamic wetting. We still do not know for example why the triangular structures form, their physical origin and the physical origin of the assumed maximum speed of wetting. Also, because it is difficult to resolve observations of dynamic wetting at this small scale, it is a significant challenge to measure accurately the dynamic contact angle and assess how and with what it changes. In this work, we report an improved technique for recording the saw-tooth wetting line as part of ongoing studies to record dynamic wetting in dip coating for air and other gases for a range of pressures from 1 atmosphere down to a few mbar. The equipment is essentially a dip coater housed inside a vacuum chamber fitted with glass windows enabling observations. The contrast at the wetting line is significantly enhanced from that shown in Fig.1 (a) to that in Fig.1 (b) by resorting to the use of white pigmented polyester base. Grazing illumination results in a decrease in light scattered by the web into the camera when set up in a direction normal to the web plane due to the presence of gas – Fig.1(c). New data are presented on (i) the air entrainment speed, (ii) the contact angle and (iii) the slope angle of the saw-tooth wetting line. These data are discussed and proposed as a basis for developing a new understanding and perhaps revised theories of dynamic wetting and its failure.

[1] Shikmurzaev's work is probably addressing the theoretical issue more comprehensively.

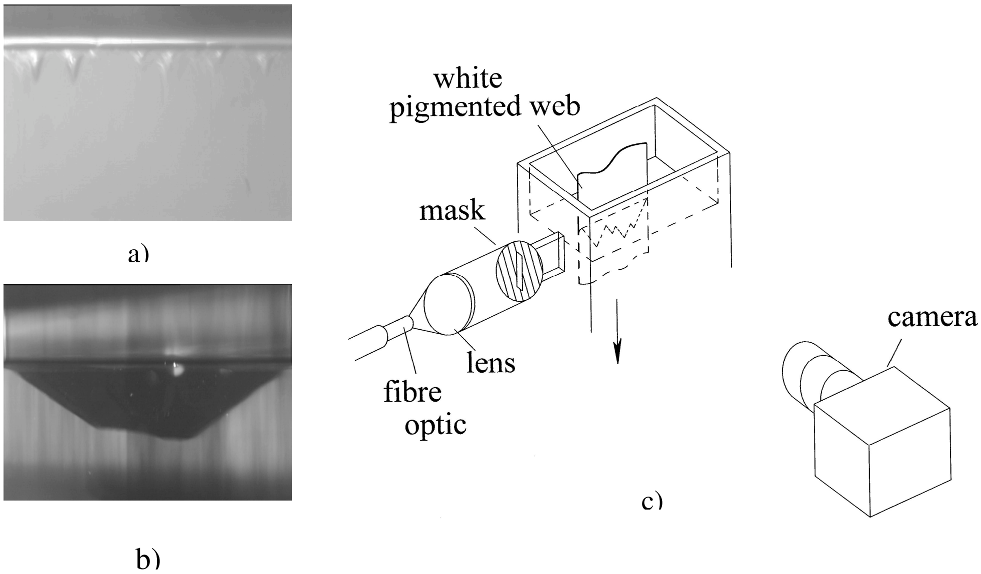

Figure 1 – Technique for Enhancing Contrast at the Dynamic Wetting Line

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