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SHORTER COMMUNICATION

MINIMUM THICKNESS OF A LIQUID FILM FLOWING DOWN A VERTICAL SURFACE—VALIDITY OF MIKIELEWICZ AND MOSZYNSKI'S EQUATION

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NOMENCLATURE

h_0^+,	dimensionless film thickness;
θ,	contact angle.

IN A RECENT communication Mikielewicz and Moszynski [1] studied the problem of rupture of a thin film flowing down a vertical surface and compared the predicted values of minimum film thickness derived from the theories of Hobler [2], Hartley and Murgatroyd [3], Murgatroyd [4] and Bankoff [5] with those obtained from their model. They concluded that comparison with experimental data on minimum film thickness was inconclusive since insufficient data were available where contact angles had been reported.

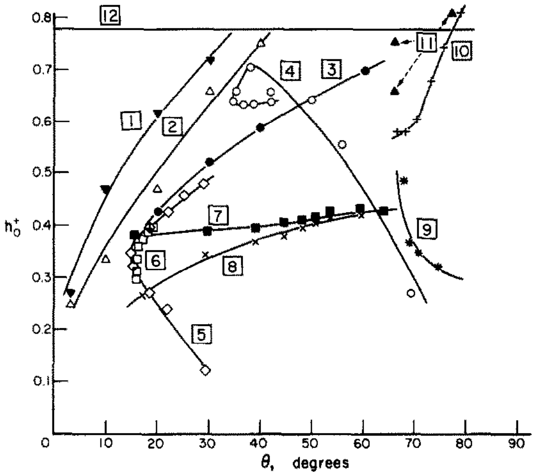

FIG. 1. Comparison of h_0^+ vs θ obtained experimentally with values predicted by Mikielewicz and Moszynski's equation. *Key*: 1. Hobler's equation; 2. Murgatroyd's force criterion; 3. Mikielewicz and Moszynski's equation; 4. Munakata *et al.* Case II; glycerol–water; 5. Munakata *et al.* Case I; glycerol–water; 6. Iijima and Kuzuoka; glycerol–water; 7. Iijima and Kuzuoka; methanol–water; pipe dia = 27.0 mm; 8. Iijima and Kuzuoka; methanol–water; pipe dia = 7.2 mm; 9. Norman, smooth copper; water 25°C; wall temp. 30–75°C; 10. Ponter *et al.*; perspex; aqueous ethanol mixtures; 11. Ponter *et al.*; stainless steel; water–ethanol absorption; 12. Murgatroyd's power criterion.

In fact such data are in existence, an inspection of which demonstrates the superiority of Mikielewicz and Moszynski's equation over that of other workers although there are some anomalies.

For example Munakata and co-workers [6] have measured and correlated wetting rate data for the glycerol–water–glass system under isothermal conditions either for when the flow rates were just sufficient to maintain a fully-wetted surface (case I) or when the liquids wetted a previously dry surface (case II). Ponter and Boyes measured the equilibrium and advancing contact angles for this system [7], Ponter *et al.* [8] having previously shown that when a film breaks an equilibrium contact angle is subtended at the apex of the dry patch which is formed with the advancing contact angle being exhibited when a liquid flows down a dry surface [9]. Iijima and Kuzuoka [10] have presented minimum wetting rate data for the systems methanol–water and glycerol–water representing a viscosity change of 1–12 cP and surface tensions of 72–26 dyn/cm, measured under isothermal conditions. The additional contact angle data required to analyse the aqueous methanol system have been recently recorded in this laboratory and are reported in Table 1.

Ponter *et al.* [8, 11] have reported minimum wetting rates to maintain a stable film for water and ethanol–water systems on vertical surfaces of copper, stainless steel, perspex and stainless steel in the presence of ethanol–air vapour mixtures. The contact angles formed by the dry patch were measured under the appropriate absorption conditions using a photographic technique. Norman and McIntyre [12] have published minimum wetting rates using water films flowing over the surface of heated vertical tubes and Ponter *et al.* [13] have measured the corresponding contact angles for conditions where heat transfer occurs.

All these data are plotted as h_0^+ vs θ in Fig. 1. It is observed that the equation of Mikielewicz and Moszynski most closely correlates the experimental values although there are deviations for the situation where water films are undergoing heat transfer. The reason for this is not clear but the introduction of a contaminating surfactant would have the maximum effect on this system.

Table 1. Contact angle data for methanol–water system at 25°C

Methanol (wt %) concentration	Equilibrium contact angle	Advancing contact angle
0	74.8	79.4
2.0	63.8	68.6
5.3	56.6	63.6
6.8	53.7	61.4
13.0	51.7	59.0
22.0	49.2	58.8
31.0	44.4	56.7
42.6	46.0	50.8
43.2	44.2	53.5
46.6	38.0	48.5
52.9	36.0	40.4
75.8	23.2	29.0
87.4	17.8	25.5
100.0	11.0	15.0

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