List of Figures

1.1 Geometry of some coating flows: (i) flow over a rotating disk, (ii) flow over a inclined plane, (iii) spreading over a substrate, (iv) blade coating, (v) flow over a vertical plate, and (vi) impinging jet flow over a surface. ................................................. 3

1.2 Schematic diagram of a spreading drop and mechanisms suggested for relieving the stress singularity at the moving three phase contact line: (a) velocity slip at the wall, (b) shear thinning transition, (c) diffuse interface, (d) molecular hopping / jumping process, and (e) precursor film. ....................................................... 5

2.1 Representation of drop surfaces .......................................................... 19

2.2 Representation of balance of interfacial forces in x-direction. .. 20

2.3 (i) Bottom radius ($a(t)$) versus time for different values of $r$ (ii) spreading rate versus bottom radius for different values of $r$. . 25

3.1 Representation of drop surfaces .......................................................... 28

3.2 The apparent contact angle ................................................................. 30

3.3 Here, ‘+’ marked and unmarked curves represent the cases of $r = 1.2$ and $r = 1.6$, respectively and dashed, solid and dash-dotted curves denote the cases of $r = 1.2$, $n = 1$ and $n = 0.8$, respectively 34

4.1 Schematic diagram of flow problem .................................................... 37

4.2 Variation of film height with $x$ at different time stage with magnetic field ($M = 2$) (dash-dot) and without magnetic field ($M = 0$) (solid) for non-uniform film profile $\delta(x) = 1 - x^2/130$ with linear stretching, while $\epsilon = 0$, $S = 0.2$ and $Fr = 0.1$ .................. 44
LIST OF FIGURES

4.3 Free surface profile at $t = 1, 5, 10, 15$ for different stretching cases: (A), (B), (C) and (D) with (dash-dot) ($M = 2$) and without (solid) ($M = 0$) magnetic field for $\delta(x) = 1 - x^2/130$, $\epsilon = 0.1$, $S = 1$, $F = 1$. Arrow shows time increment. ........................................ 45

4.4 The horizontal component of velocity profile $u$ at $x = 7$ for different times, $t = 5$ (solid), $t = 10$ (dash) and $t = 15$ (dash-dot) for different types of stretching cases (A), (B), (C) and (D) with $\delta(x) = 1.0$, $\epsilon = 0.1$, $S = 1.0$, $M = 0$ (unmarked), $M = 0.3$ (marked ‘+’) and $Fr = 1.0$. ......................................................... 46

4.5 Same as mentioned in the caption of Figure 4.4 but at $x = 3$. .......... 47

4.6 Same as mentioned in the caption of Figure 4.4 but at $x = 2$. ......... 48

4.7 Blocks I and IV represent the development of velocity at different time levels (arrow indicates for increasing time) at $x = 2$, Blocks II and V represent the development of velocity at $x = 3$ and Blocks III and VI represent the corresponding film development with same increasing time for the stretching case C with $\delta(x) = 1$, $\epsilon = 0.1$, $S = 1.0$, $M = 0$ and $Fr = 1.0$. ........................................ 49

4.8 Blocks I and IV represent the development of velocity at different time levels (arrow indicates for increasing time) at $x = 2$, Blocks II and V represent the development of velocity at $x = 3$ and Blocks III and VI represent the corresponding film development with same increasing time for the stretching case C with $\delta(x) = 1$, $\epsilon = 0.1$, $S = 1.0$, $M = 0.3$ and $Fr = 1.0$. ..................... 50

4.9 Variation of $h_x$ and $h_{xxx}$ against $x$ at different time levels for $M = 0$. Other details are same as previous figure. ................. 51

4.10 Variation of $h_x$ and $h_{xxx}$ against $x$ for two different values of Hartmann no. at different time levels. Other details are same as previous figure. ........................................ 52

5.1 Schematic diagram of the flow problem................................. 55
5.2 Film profile $h$ versus $x$ at $t = 28.0$ for different values of Marangoni number ($M_w = 2$ (solid line) and $M_w = 8$ (dash line)) and Hartmann number ($M = 0$ (unmarked) and $M = 2$ ('o' sign marked)) under different stretching velocities. Sheet temperature $\Theta = 1 - \exp^{-\frac{5}{3}}$, initial film profile $\delta(x) = 1$, $\epsilon = 0.05$, $S = 2$, $Fr = 2$, $B = 1$ and $Pr = 1$.

5.3 Temperature profile at interface $h$ versus $x$ at two different time levels $t = 0.4$ and $t = 2.0$ for two different values of Hartmann number ($M = 0$ (solid line) and $M = 2$ (dash line)) under stretching velocity $U(x) = 0.6(0.1x + 0.01x^2)$. Sheet temperature $\Theta = 1 - \exp^{-\frac{5}{3}}$, initial film profile $\delta(x) = 1$, $\epsilon = 0.05$, $S = 2$, $Fr = 2$, $B = 1$ and $Pr = 1$.

5.4 Film profile $h$ versus $x$ at $t = 0.3$ and $t = 0.4$ for different values of Marangoni number ($M_w = 4$ (solid line) and $M_w = 10$ (dash line)) and Hartmann number ($M = 0$ (unmarked) and $M = 2$ ('o' sign marked)). Sheet temperature $\Theta = 0.6 + 0.5\sin(2\pi x/10)$, initial film profile $\delta(x) = 1$, sheet velocity $U = x$, $\epsilon = 0.05$, $S = 2$, $Fr = 2$, $B = 1$ and $Pr = 1$.

5.5 Film profile at $t = 1$ for $Pr = 1$ (solid line) and $Pr = 15$ (dash line), $M = 0$ (Unmarked) and 2 ('o' marked). Sheet temperature $\Theta = \exp^{-\frac{5}{3}}$, initial film profile $\delta(x) = 1$, sheet velocity $U = x$, $\epsilon = 0.05$, $S = 2$, $Fr = 2$, $B = 0.1$ and $M_w = 10$.

5.6 Evolution of the film profile $h$ for different values of Hartmann no. ($M = 0$ (solid) and $M = 2$ (dashed)) and the smoothed step function type temperature distribution $\Theta = 0.5(1 + \tanh(35(2.5 - x)/10)$ from $t = 1$ to $t = 20$ with increments of 1. Here, initial film profile $\delta(x) = 1$, sheet velocity $U = 0.1x$, $\epsilon = 0.05$, $S = 2$, $Fr = 2$, $B = 1$ and $M_w = 4$.

6.1 Schematic diagram of the flow problem.

6.2 Plot of $H_2 \delta$ and $H_1$ for $m = 1.1$, $n = 1.6$, $Re_1 = 0.05$ and $\delta = 1$.

6.3 Plot of lower layer ($H_1$) and upper layer thickness ($H_2 \delta - H_1$) with time ($\tau$) for $m = 1.1$, $n = 1.6$, $Re_1 = 0.05$ and $\delta = 1$. 
6.4 Here, solid and dashed lines represent of radial velocity of lower layer and upper layer, respectively for $m = 1.1, n = 1.6, Re_1 = 0.05$ and $\delta = 1$. .............................................. 82

7.1 Schematic diagram of the flow problem.................................................. 85

7.2 Variation of top film's height ($H_2\delta$) and the bottom film (interface height $H_1$) with $\tau$ for three different values of $\delta$. Solid, dashed and dashed-dotted lines represent for $\delta = 1.2, 1.0$ and 0.9, respectively. While $m = 1.6, n = 1.4$ and $Re_1 = 60$ are considered as fixed. .... 94

7.3 Variation of top film’s height ($H_2\delta$) and the bottom film (interface height $H_1$) with $\tau$ for two different values of $n$. For total layer, dotted and solid lines represent film thickness for $n = 3.5$ and 6.0, respectively. Dashed and dashed-dotted lines representing the lower layer thickness for $n = 3.5$ and 6.0, respectively. While $m = 2.0, Re_1 = 10.0$ and $\delta = 1.0$ are considered as fixed .................... 95

7.4 Variation of top film’s height ($H_2\delta$) and the bottom film (interface height $H_1$) with $\tau$ for two different values of $m$. Here, dotted and solid lines represent total film thickness for $m = 1.4$ and 2.0, respectively. Dashed and dotted-dashed lines represent lower layer thickness for $m = 1.4$ and 2.0, respectively. While $n = 2.5, Re_1 = 10.0$ and $\delta = 1.0$ are considered as fixed ...................... 96

7.5 Variation of top film's height ($H_2\delta$) and the bottom film (interface height $H_1$) with $\tau$ for two different $Re_1$. Here, dotted and solid lines represent total film thickness for $Re_1 = 0.5$ and 0.9, respectively. Dashed and dotted-dashed lines represent lower layer thickness for $Re_1 = 0.5$ and 0.9, respectively. While $m = 2.0, n = 2.5$ and $\delta = 1$ are considered as fixed. ........................................ 97

7.6 Variation of $G_2$ at free surface ($H_2\delta$) and $G_1$ at interface ($H_1$) with time $\tau$ for two different $Re_1$. Dashed and solid line represent $Re_1 = 0.5$ and $Re_1 = 0.9$, respectively. While $m = 2.0, n = 2.5$ and $\delta = 1.0$ are considered as fixed. ........................................ 98
7.7 Variation of $F_2$ at free surface ($H_2\delta$) and $F_1$ at interface ($H_1$) with time $\tau$ for two different $Re_1$. Dashed and solid line represent $Re_1 = 0.5$ and $Re_1 = 0.9$, respectively. While $m = 2.0$, $n = 2.5$ and $\delta = 1.0$ are considered as fixed. ............................................................... 99

7.8 Variation of $G_2$ at the free surface ($H_2\delta$) and $G_1$ at the interface ($H_1$) with time $\tau$ for three different $\delta$. Solid, dashed and dotted - dashed lines represent $\delta = 1.2$, 1.0 and 0.9, respectively. While $m = 1.6$, $n = 1.4$ and $Re_1 = 6.0$ are considered as fixed. ....... 100

7.9 Variation of $F_2$ at free surface ($H_2\delta$) and $F_1$ at interface ($H_1$) with time $\tau$ for three different $\delta$. Solid, dashed and dotted - dashed line represent $\delta = 1.2$, 1.0 and 0.9, respectively. While $m = 1.6$, $n = 1.4$ and $Re_1 = 6.0$ are considered as fixed ....... 101

A.1 Representation of drop surfaces ............. 103
A.2 Partial wetting and complete wetting ......... 104

B.1 Geometry of spherical cap and ice cream cone ............. 106