sion and capillary forces have been neglected during bulk drainage of the washcoat. If most of the initially wetted surface area remains wetted during the drainage cycle, the omission of capillary forces has a negligible effect on the accuracy of the model. However, if appreciable wicking takes place such that significant areas of once wetted channel form a wet/dry interface, then capillary forces will become more significant.

[0184] The thickness estimate is only valid in the center of a channel wall face, i.e., away from corners and other more complex topology.

[0185] Model Results

[0186] Drainage Rate

[0187] For essentially all credible values for washcoat physical properties and channel dimensions, gravitational drainage flow rate is virtually steady state within a distance of several hydraulic diameters below the initial fill level. An analytic expression below is provided for the average flow velocity. This flow velocity (or alternatively another flow velocity if flow is pump assisted) is used in the initial film thickness calculation.

[0188] Initial Film Thickness

[0189] The model used at present for initial film thickness is a function solely of the average drain velocity and fluidic properties of the washcoat. It has no geometry dependence. An alternative expression for initial film coat thickness that could potentially use both the hydraulic diameter and length of the channel is discussed but not used at present because it appears to be giving unreasonable results.

[0190] Time and Spatially-Dependent Film Thickness

[0191] The model indicates that the wet washcoat thickness varies as $(z/t)^{1/2}$ where z is the axial location below the fill level in the channel and t represents the elapsed time following the bulk drainage of fluid out of the channel. Model input parameters include washcoat viscosity, density, and the local acceleration of gravity. The model is judged to be applicable only during the initial stages of washcoat application where gravitational effects dominate wall adhesion and vertical capillary forces.

[0192] Model Summary

[0193] An analytical solution to the partial differential equations describing a liquid falling film along the sides of a channel that has been filled and drained has been obtained. The model requires the following input parameters: (1) liquid viscosity, (2) liquid density, (3) angle of inclination relative to the direction of gravitational attraction, and (4) local acceleration of gravity. The variables in the solution are (1) the axial location measured from the fill mark in the direction of gravitational attraction and (2) the time elapsed since bulk drainage of the channel took place (i.e., the time since the interior liquid filling the channel had been removed and now only excess liquid clings to the sides of the wall). The model predicts the reduction in liquid thickness as a function of time for a given axial location as washcoat drains down the side of the channel when gravitational attractions dominates wall adhesion and capillary effects.

[0194] Conclusions and Recommendations

[0195] Parameter studies using the tool and inspecting the equation solutions suggest the following implications for the washcoat process if capillary features are not present on the walls of an otherwise smooth microchannel wall:

[0196] Fluidic Properties

- **[0197]** Density: increased density increases the initial film thickness but also increases the rate of thinning
- **[0198]** Viscosity: Higher viscosity results in greater initial film thickness and a lower rate of thinning
- **[0199]** Surface tension: Increased surface tension decreases initial film thickness but has little impact on film thinning rate
- **[0200]** Contact angle: Second order effect on film thinning (3% to 10% change in film thickness)

[0201] Channel Dimensions

- **[0202]** Hydraulic diameter: larger channel diameter results in a thicker initial film layer—but has negligible effect on thinning rate
- **[0203]** Length: longer channels result in more washcoat non-uniformity

[0204] Force Contribution

- **[0205]** Gravitational and viscous loss forces dominate and balance one-another to give a nearly constant drain rate
- **[0206]** Capillary forces in the vertical direction are second order and play a role at the top of the liquid column between wetted and dry surfaces. They are also expected to play a role during draining, where fluid will be held up near the bottom of the microchannels.

[0207] Property Contributions

- **[0208]** Viscosity plays largest role in determining initial and final layer thickness
- **[0209]** Density is next largest contributor with increasing density resulting in thicker initial film later compensated by higher rate of film thinning
- **[0210]** Surface tension plays a significant role only during formation of the initial residual film layer but has negligible effect on film thickness after several minutes

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