[0079] "Mass of fluid entering a surface feature" is defined as the amount of mass at the inlet to a surface feature section that enters at least one surface feature in a surface feature section, wherein entering a surface feature means the fluid molecule breaks the plane of the recessed surface feature and moves out of the bulk flow channel. Computational fluid dynamics (CFD) code should be used to evaluate the percentage of mass that enters at least one surface feature in a surface feature section, which allows the evaluation of the fluid flow path lines to be illustrated and traced through the surface feature section. The surface feature section should be discretized with a minimum of 6 volume cells in the depth and length directions to get reasonable flow discretization, with the main straight channel discretized with proportionally sized cells to maintain the cell size continuity in the channel adjacent to the surface features and the spaces between the surface features. The correct hydrodynamic model should be used for the inlet stream velocity and cross-section. The solution should be well converged, with the total sum of all of the inlet mass flow rates compared to the total outlet mass flow rates should be within 0.0001% of each other and with the energy balance of that entering the system must equal that which is leaving should be with in 1% of each other. The CFD code should evenly distribute at least 100 path lines evenly over the cross-section of the channel at the inlet of the channel. The percentage of the path lines that enter at least one surface feature are in turn a representation of the mass percentage that enters at least one surface feature.

[0080] Main channel: an open path for bulk flow.

[0081] (Main) channel width: the largest dimension of the cross section of a rectangular main channel.

[0082] (Main channel) gap: the smallest dimension of the cross section of the main channel.

[0083] Main channel mean bulk flow direction: the average direction of the flow along a portion of the main channel for flow traveling from inlet to outlet.

[0084] The Reynolds number, Re, is the commonly used ratio of the inertial over the viscous forces seen by flow in a channel. Its definition is the ratio of the mass flux rate (G) times the hydraulic diameter (D) divided by the dynamic viscosity (μ),

$$\mathrm{Re} = \frac{GD}{\mu} = \frac{\rho U D}{\mu} \quad (1)$$

The value of the Reynolds number describes the flow regime of the stream. While the dependence of the regime on Reynolds number is a function of channel cross-section shape and size, the following ranges are typically used for channels: Laminar: Re<2000 to 2200; Transition: 2000-2200<Re<4000 to 5000; Turbulent: Re>4000 to 5000.

[0085] "Unit operation" means chemical reaction, vaporization, compression, chemical separation, distillation, condensation, mixing, heating, or cooling. A "unit operation" does not mean merely fluid transport, although transport frequently occurs along with unit operations. In some preferred embodiments, a unit operation is not merely mixing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0086] FIG. **1***a* illustrates a surface feature pattern with alternating series features for shifting flow across a microchannel.

[0087] FIG. **1***b* illustrates a series of like features in a surface feature pattern.

[0088] FIG. **1***c* illustrates some options for patterns formed by opposing surface features.

[0089] FIG. **1***d* illustrates some possible shapes for surface features.

[0090] FIGS. **2***a*-**2***e* illustrate various patterns for capillary/surface features.

[0091] FIGS. **3***a*-**3***k* illustrate various patterns for surface features.

[0092] FIG. **4***a* is a top view of different surface feature patterns which, when stacked in adjacent layers, form a layered surface feature.

[0093] FIG. **4***b* front view of 3-D surface features where recessed chevrons abut the bulk flow mirochannel and have additional features of different shapes behind them at varying depths and locations.

[0094] FIG. **5** illustrates subpatterning on surface features for increasing surface area.

[0095] FIG. **6** shows a surface feature pattern that was analyzed in the Examples.

[0096] FIG. **7** illustrates the heat transfer enhancement resulting from the surface feature pattern of FIG. **6**.

[0097] FIG. **8** shows the improvement in methane conversion of surface features versus no surface features.

[0098] FIG. **9** illustrates pressure drop with and without surface features.

[0099] FIG. **10** illustrates the relationship of pressure drop and Reynold's number with and without surface features.

[0100] FIG. **11** is a comparison of measured and predicted uptake per coating for the expected liquid surface with a 45 degree contact angle and for capillary features which completely fill with washcoat liquid (full groove).

[0101] FIG. **12** illustrates a comparison of catalyst uptake on flat coupon (FC) versus those with 5 mil (127 micron), 3 mil (76 micron) or 1 mil (25 micron) deep capillary features.

[0102] FIG. **13** illustrates an assembly of a testing device body and inserted coupon

[0103] FIG. **14** accompanies an example showing the variation of ratio of heat transfer coefficient increase to pressure drop increase as a function of Reynolds number

[0104] FIG. **15** illustrates particle release location for an example.

DETAILED DESCRIPTION

[0105] "Surface features" are recesses in (or, in less preferred embodiments, projections from) a microchannel wall