Transition into subdynamic regime in pressure-driven microfluidics

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Abstract

Because of their small size, and often also the high viscosity of handled fluids, such as those encountered in biomedical applications, quite often microfluidic devices have to operate at very low Reynolds numbers. Those fluidic devices the operation on which based on using inertia of deflected jet at low Reynolds numbers lose their efficiency. In the extreme case the devices exhibit a phenomenon so far rarely if at all not discussed in literature: they enter a regime in which their behaviour, characterised by the character of their flowfield, ceases to vary with varied Reynolds number. Contribution concentrates on a particular example of a fluidic valve for by-pass flow control. Detailed description and discussion of this case in particular focuses on a substantial change in behaviour associated with the transition into the sub-dynamic regime. In a related example, the performance at very low Re could be re-established by pressure-assisted operation mode, with a driving constant pressure difference forcing the fluid into the output terminal of the discussed valve. For characterisation of this pressure action was introduced a newly derived dimensionless pressure parameter (ratio of pressure forces and viscous forces acting on an element of the fluid. The real improvement of performance was, however, not significant enough and the desirable control action effect had to be obtained by very strong input control flow, which has led to the somewhat paradoxical concept of fractional flow rate gain.

Keywords: microfluidics, jet, fluidic valve