ASCOMP

MULTIPHASE FLOW SCIENCE AND TECHNOLOGY

Microfluidics

Microchannel flows, Flow control in bio-chips, Heat management using enhanced-surfaces materials, Drop on demand in microfluidic chips

AT

Micro-Tech

TransAT has from the start been successfully employed by the ASCOMP Services Team to model microfluidics flow systems involving phase change and transition. TransAT's predictive capabilities of small-scale interfacial flows featuring heat transfer phase change enable tackling a wide range of such applications.

Microchannel flows

Two-phase flow microchannel heat sinks are used to cool high power density power systems, because latent heat during the phase-change process is leveraged to capture and transfer high heat fluxes. But the implementation of two-phase microchannels is challenging due to the instability of the vapor-liquid interfaces, leading to local dry-out and thus poor cooling efficiency. Modelling microfluidic flows at reduced length scales require the use of advanced multiphase flow techniques such as in TransAT, combined with appropriate microscale physics models, in particular wetting.

Heat management using enhanced-surfaces materials

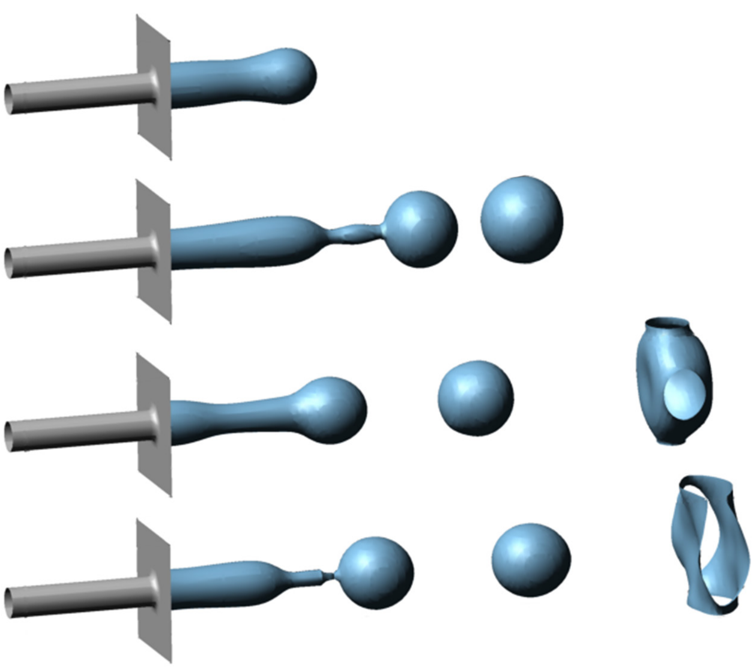
Enhanced surfaces materials are employed for efficient heat channeling. Another strategy for dissipating the heat is to use anisotropic thermal conductive thin layers to guide the heat to the sink. The idea is inspired by heat transport by magnetic excitations in quasi 1D insulating materials. The magnetic conduction is highly anisotropic, and has mostly been studied in novel transition metal oxides with 1D spin structures. In TransAT, heat transfer on such materials could be modelled, including in two-phase flow.

MicroChannel heat exchangers

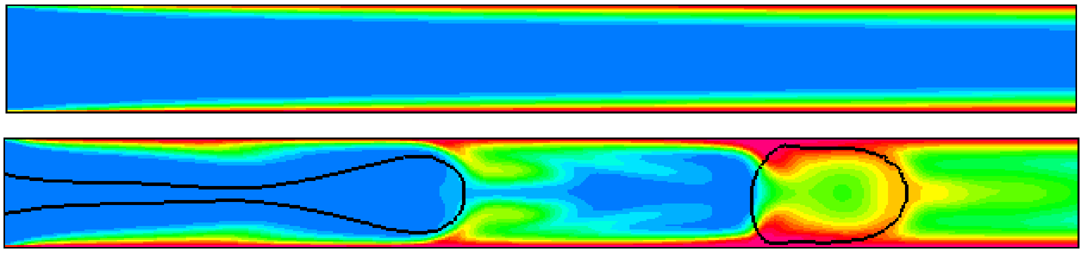
MicroChannel or Micro-scale heat exchangers (MCHE) are heat exchangers in which (at least one) fluid flows in lateral confinements with typical dimensions ~1 mm. MCHE can be used for many applications including aircraft gas turbine engines, heat pumps, air conditioning systems, heat recovery ventilators. The MCHE is highly efficient, resulting in up to 30% less refrigerant charge compared to other heat exchangers. First simulation trials on prototypes using TransAT proved rather satisfactory, and are now extended to real design conditions.

Heat pipes

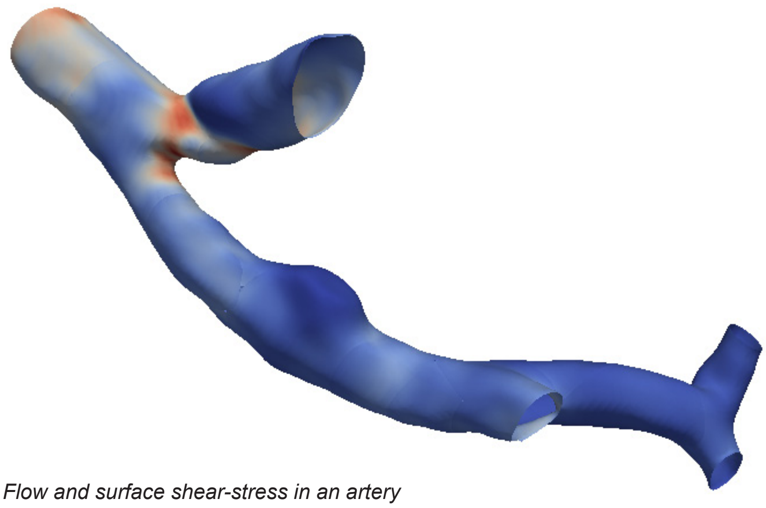
These highly effective thermal conductor devices involve thermal conductivity and phase change together. They are proved to be useful to efficiently manage the transfer of heat between two solid interfaces. At its hot interface the liquid evaporates by absorbing heat from that surface, which then travels along the heat pipe to the cold wall and condenses back. The cycle repeats itself through capillary, centrifugal or gravity forces. With its combined compressible-multiphase-phase change capabilities, TransAT can be used to model the entire cycle.



On-demand micro droplet dispenser



Heat transfer in 1 mm diameter pipe with gas-liquid slug flow



Flow and surface shear-stress in an artery

Med-Tech

Flow control in Med-Tech systems is central to future advances such as biological reactors, micro-reactors, bio-channel arrays, or lab-on-a-chip devices. TransAT has proven to be highly effective in predicting this class of flows thanks to its predictive capabilities of falling films, spreading and de-wetting of liquids, chemical reaction of binary mixtures, micro-bubbles and droplet control.

Drop-dispensing on demand

In-chip drop on demand consists in dispensing picoliter to nanoliter drops in the channels of a microfluidic chip at frequencies up to 2.5 kHz with precise volume control. Several features of the technique have direct relevance to lab-on-a-chip applications. Individual microdrops can be dispensed from the chamber to the channeling system in various modes. The efficiency of micro-dispensers is measured in terms of frequency and droplet size, which directly depend on the way capillary forces are modelled. Many successful examples were treated by TransAT.

Flow control in Bio-chips

The control drops carrying reagents in miniaturized bio-chips is a hot theme in the Medtech sector. The concept, where a tiny fluid microprocessor performs complex tasks relevant to chemistry or biology, has been a subject of academic interest, and there are encouraging signs that industrial lab-on-a-chip applications are growing. The control can be achieved by wetting, Marangoni effects, or via imposing an external magneto-electrical or acoustic field. The predictive capacity of TransAT in treating these subjects has been proven via various examples.

Droplet microfluidics crystallization of API

Solution crystallization is one of the most widely used separation process in the chemical and pharmaceutical industries and is now being replaced by more efficient, cost-saving alternatives, including individual droplet crystallization in microfluidics. The design of new techniques of crystallization based on droplet microfluidics will eliminate various intermediate steps in the preparation, thus shortening time to market and saving millions to the fabricants. With its detailed simulations, TransAT is expected to play an important role in this revolution.

Cardiovascular and arterial blood flow motion

Advances in medical imaging and CFD techniques make it possible to simulate blood flow and pressure in arterial models built from patient data. The combination of these technologies offers the possibility of calculating pressure gradients and shear stresses at crucial locations noninvasively. Remarkable results have been obtained with TransAT in studies of heart flows, aneurysms, ventricle flows and particulate deposition in airways.

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India - RahulCom
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Middle East - Halhoul
ala_t25@yahoo.com

South Korea - U . I . T . Inc.
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