

MULTI-SCALE MODELLING OF REACTING GAS FLOWS IN MICRO-FLUIDIC SYSTEMS

PROJECT LEADERS

CR Kleijn

RESEARCH THEME

Complex dynamics of fluids
Mathematical and computational
methods for fluid flow analysis

PARTICIPANTS

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COOPERATIONS

MicroNed, TNO Defence and
Security, TNO Science and Industry
TU Delft Dept. Aerospace Engng.

FUNDED

MicroNed
1st - 2nd - 3rd 100%

START OF THE PROJECT

2006

INFORMATION

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PROJECT AIM

The goal of this project is to develop numerical simulation tools, based on hybridizations of classical CFD and Direct Simulation Monte Carlo, for reacting gas flows in microfluidic systems. The special focus of the project will be on the study of micro thrusters and micro combustors.

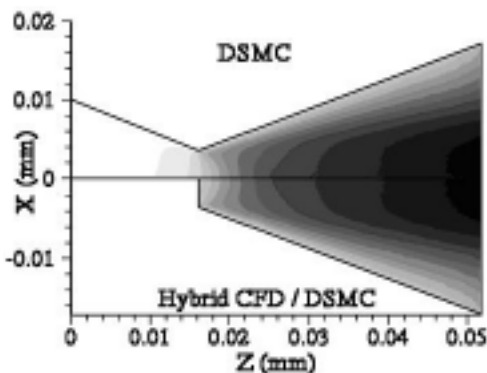
PROGRESS

A computational study has been performed on the hydrodynamics of MEMS fabricated convergent-divergent micro-nozzles with thrusts in the N range. At these small dimensions, the gas flow in the divergent is rarefied. Hybrid simulations have therefore been performed, in which continuum based CFD is performed in the convergent part of the nozzle, and molecular DSMC simulations are performed in the divergent part of the nozzle. So far, one way coupling has been realized only, in which pressure and velocity at the throat as obtained from CFD are used as inlet boundary conditions for DSMC. It has been demonstrated that using CFD simulations in both the convergent and divergent leads to inaccurate results, even if slip flow boundary conditions are employed. Predicted thrusts were found to sensitively depend on the thermal and momentum accommodation coefficients of the gas molecules on the nozzle walls.

DISSERTATIONS

SCIENTIFIC PUBLICATIONS

1. Federico La Torre, Sasa Kenjeres, Jean-Luc P.A. Moerel, Barry T.C. Zandbergen and Chris R. Kleijn. "Influence of Boundary Layer Formation and Surface Roughness on the Thrust of Micro-Nozzles" In: G. Saccoccia and P.-G. Amand (editors), Proceedings of "Space Propulsion 2008 (5th International Spacecraft Propulsion Conference and 2nd International Symposium on Propulsion for Space Transportation)", Heraklion, Crete, Greece, 5-8 May 2008.
2. J.L.P.A. Moerel, H.M. Sanders, M.C. Louwerse, H.V. Jansen, J. Boscher, B.T.C. Zandbergen, F. La Torre, S. Kenjeres and C.R. Kleijn. "Development of Micro Propulsion System Technologies for Minisatellites in the Netherlands" In: G. Saccoccia and P.-G. Amand (editors), Proceedings of "Space Propulsion 2008 (5th International Spacecraft Propulsion Conference and 2nd International Symposium on Propulsion for Space Transportation)", Heraklion, Crete, Greece, 5-8 May 2008.



Comparison of Mach number contours from the solution obtained by full DSMC, and by DSMC in the divergent only with inlet boundary conditions in the throat plane obtained from CFD.