Universität Rostock

Traditio et Innovatio

Numerical and experimental flow analysis in centifluidic systems for rapid allergy screening tests

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Introduction

Within the BMBF initiative “Innovative Regional Growth Cores (German: Innovative regionale Wachstumskerne): Centifluidic Technologies”, in collaboration with the DST Diagnostische Systeme GmbH, an automated processing for a membran-based rapid allergy test is developed.

DST is a specialist in diagnostics solutions for the detection of allergies and food intolerances. Fluidics of the rapid test FastCheckPOC® 20 (FCP20) were significantly optimized in cooperation with the chair of fluid technology and microfluidics. FCP20 is an ELISA protocol for the semi-quantitive determination of allergen specific IgE. With a range of 20 test parameters, FCP covers over 90% of the most frequently occurring allergies in central and northern Europe. So far, this test was used by a complex and manual handling.

The aim of this project is to develop a concept for an automated test execution of the FCP20.

Fig. 1. FastCheckPOC®20 (FCP20) Test Kit

Fig. 2. Experimental flow analysis in the pipes of the FCP20

Method

The concept of the automated test execution contains a modular design, consisting of the FCP20 (1), a disposable reagents module (2, RM) and a multiple usable stationary unit (3), which delivers the operating liquid (see Figure 3).

In the current sub-project the focus is on the reagents module (2). It consists of several inputs and channels, through which liquid reagents pass one after another. The channels have a thickness of at least 2mm with a flow rate up to 60 ml/min.

In previous studies a return flow from one input-channel into the other input-channels has been observed, which would lead to erroneous results of the allergy test. The main objective is to avoid a return flow without using active components like valves.

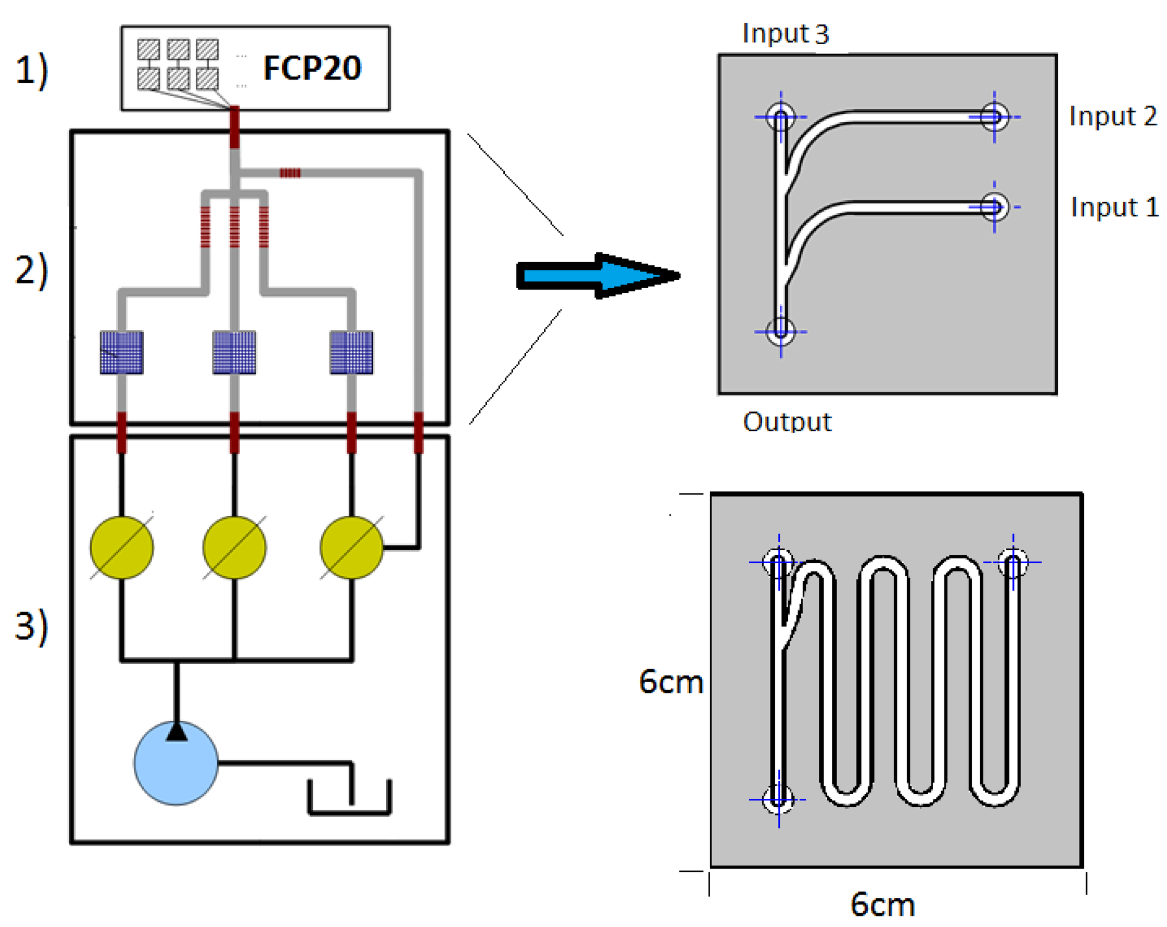

Fig. 3. Schematic structure of the modular design (left); reagents module with 2 geometric solution (right)

Numerical and experimental analysis

In a previous study hydrophobic surfaces were investigated. But these elements did not show any functionality. The current approach proves only geometrical solutions. This included pointed channels at an angle of 12° (see Figure 3, right top) and meander-shaped channels (see Figure 3, right bottom).

These two options were simulated with computational fluid dynamics (CFD). CFD is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. The validation was based on experimental data of the contact angle Θ and the dynamical flow behaviour.

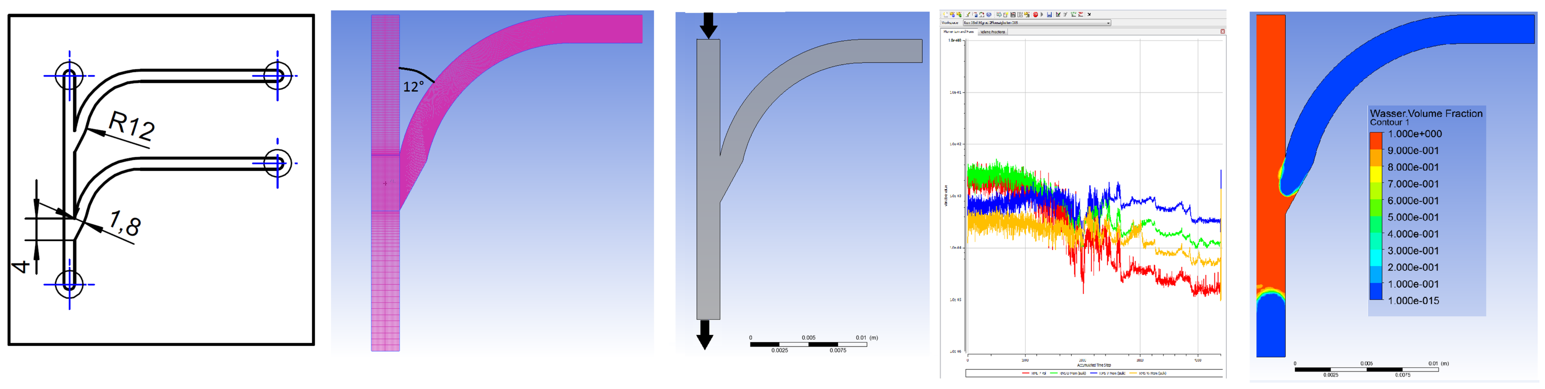

Fig. 4. Individual steps of a CFD-calculation for this problem (left to right)

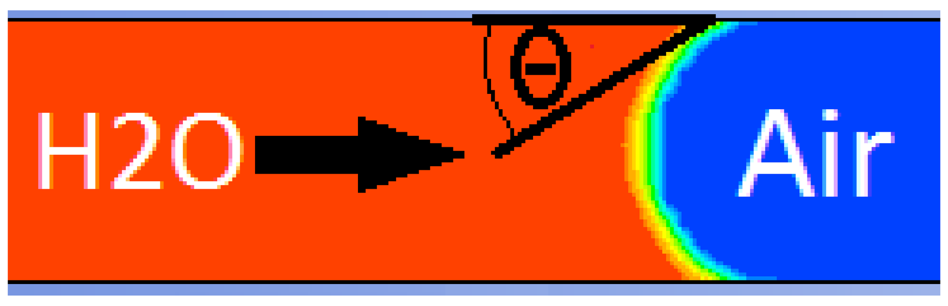

Fig. 5. CFD: Water flow with convex meniscus in the channel

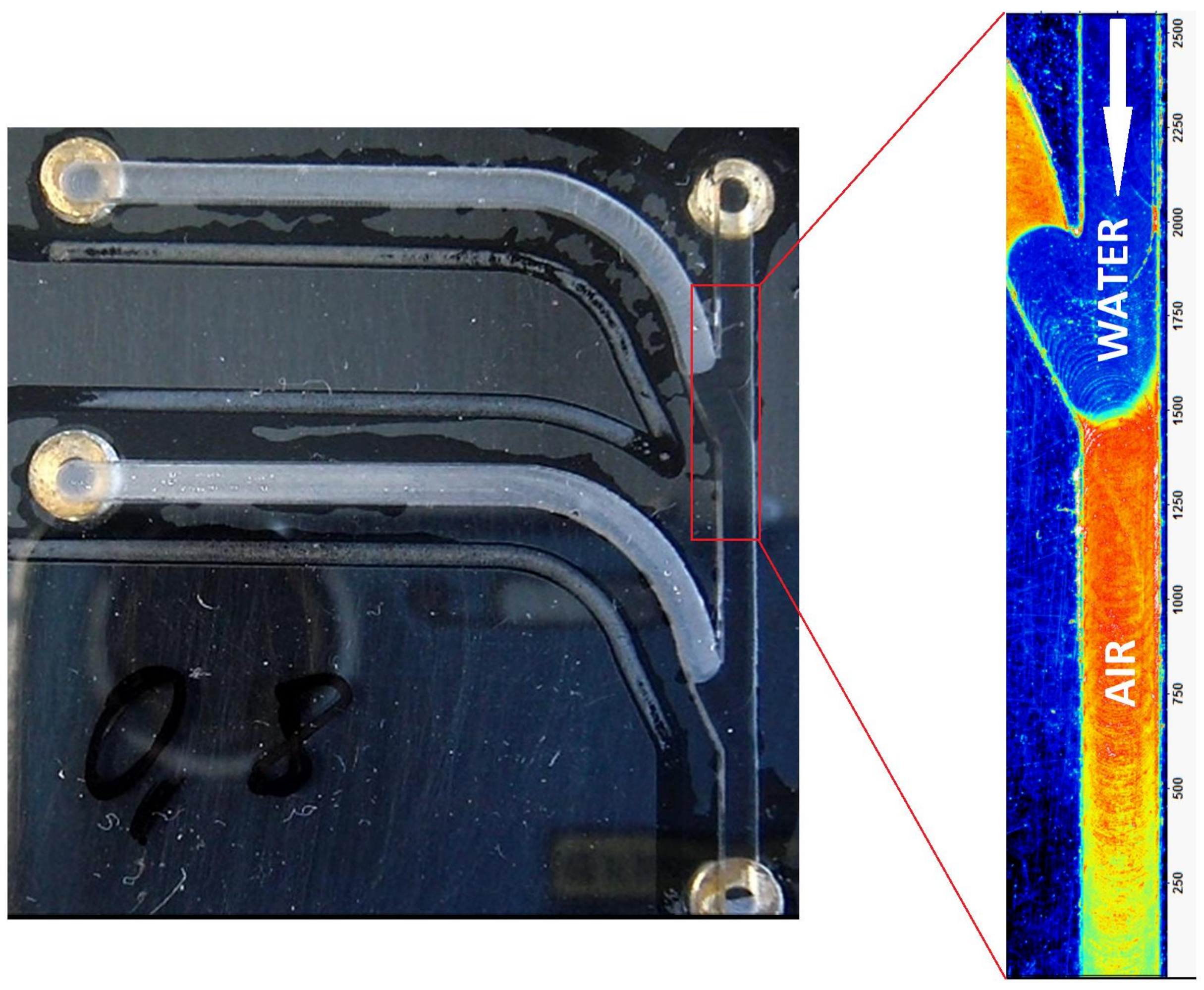

Fig. 6. Experimental studies of the flow behaviour

Conclusion

The results of the CFD-simulation and the experimental studies show that at a low volume flow the probability for the flow returning into another channel also decreases. Only at flow rates over 35ml/min a return flow appears. Differences between the pointed channels and the meander-shaped channels are not visible. Comparisons of measurements and simulations show good agreements. Further validations are in progress

The geomtetrical solution of the pointed channels for the reagents module seems to be a good alternative for avoiding active components like valves.

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