IN-LINE MICRO BALL VALVE THROUGH POLYMER TUBING

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Abstract

A magnetically driven in-line micro ball valve through polymer tubing has been realized in this work. The structure is symmetric so that it can be used bi-directionally and it is very simple making it easily connectable with other microfluidic systems.

Keywords: Ball valve, microvalve, polymer tubing

1. Introduction

This paper presents an in-line micro ball valve using polymer tubing, as shown in Figure 1. Recently, a ball microvalve using electromagnetic actuation was reported [1]. However, tight sealing was difficult to achieve using the silicon valve seat. In this work, to realize a tighter and mechanically more stable valve seat, polymeric material was used for that valve seat. This enhances the sealing of the outlet orifice and results in lower leakage.

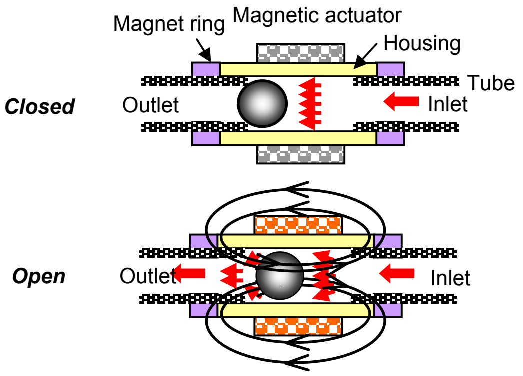

Figure 1. Schematic diagram of an in-line micro ball valve through polymer tubing.

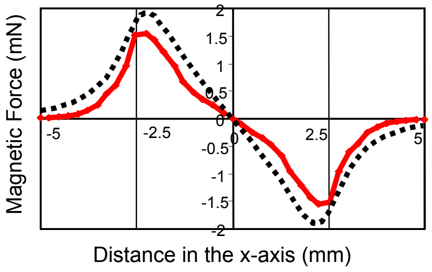

Figure 2. Analytically calculated result (dashed line) and the MagNet® simulation result (solid line). a = 0.8 mm, l = 5 mm, I = 1 A, N = 500, the diameter of wire = 0.2 mm, the diameter of nickel ball = 760 µm.

2. Design

Figure 2 shows an analytically calculated magnetic force on the spherical metal ball exerted by the magnetic actuator along the x-direction. In addition, the force of attraction on the ball is plotted as a function of displacement by the MagNet® simulation. The ball has to be placed slightly inside the end of the magnetic actuator, where the maximum magnetic force is achievable. Figure 3 shows computational fluid dynamics simulation results at static position where the ball is 100 µm and 300 µm distant from the outlet. The simulation results

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show that the flow rate increases with increasing gap of the metal balls from the outlet.

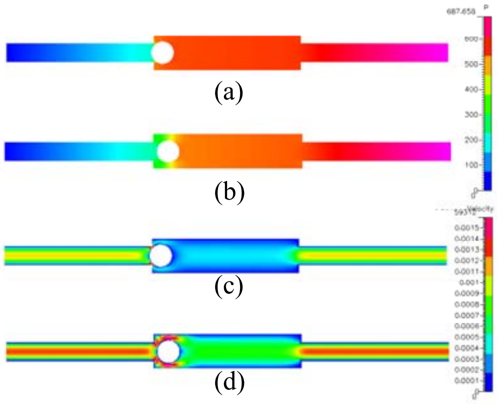

Figure 3. CFD-ACE® simulation results: the pressure drop profiles when the balls (a) 100 µm and (b) 300 µm distance from the outlet, respectively; The fluidic velocity profiles when the ball is (c) 100 µm and (d) 300 µm distance from the outlet, respectively.

3. Experimental Results

Based on these simulation results, an in-line micro ball valve was realized, which consisted of biomedical grade silicone tubes (625 µm ID and 1190 µm OD), a nickel ball with a diameter of 760 µm, and a Teflon tube for housing. Figure 4 shows the experimental result of the leakage flow rate as a function of the input pressure with DI water. Although this device is not appropriate for the application in low ranges of input pressure, by adding an electromagnet ring or a permanent magnet ring around the outlet position, much less leakage flow rate may be achievable. Figure 5 shows flow measurement result at an input pressure of 0.3 psi. If the actuation current is larger, the ball can travel further upstream, which makes a larger gap between the outlet orifice and the ball, and fluids flow at higher flow rates. So, the flow rate was controllable by the actuation current.

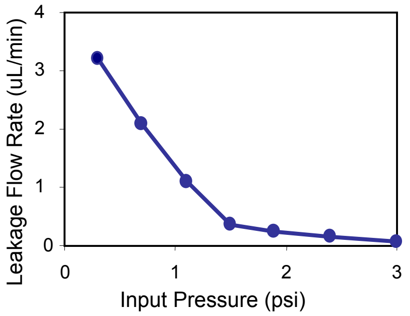

Figure 4. Leakage flow rate vs. the input pressure for DI water.

4. Conclusions

An in-line magnetically driven normally-closed ball microvalve using polymer tubing has been realized in this work. The structure is symmetric so that it can be used bi-directionally and it is very simple making it easily connectable with other microfluidic systems. Thus, the new micro ball valve developed in this work will have tremendous applications in various bio/chemical microfluidic systems.

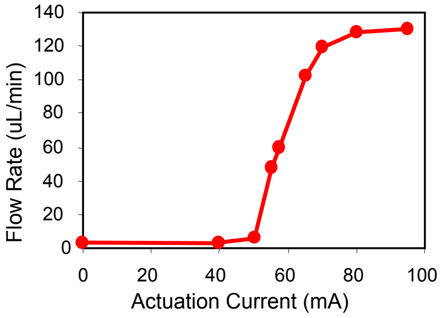

Figure 5. Flow rate vs. the input pressure for DI water at 0.3 psi input pressure.

Acknowledgements

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References

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