CONSTANT-PRESSURE DISPENSING UNIT FOR MICROFLUIDIC APPLICATIONS

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Introduction

This paper presents the design, fabrication, and testing of constant pressure liquid dispensing units that can be integrated with microfluidic channels. The liquid dispenser serves dual purpose of a reservoir and a micropump. The dispensing system consists of a 1cc capacity Parylene bellows, which stores the working liquid, and a novel spring driven actuating mechanism, which pumps the liquid at a constant inlet pressure of 6.5 psig. To maintain constant pressure at the outlet of the dispenser, constant force springs are used. As seen in Figure 1, the mechanism is similar to a reciprocating pump. The dispensing unit is initially charged with the working liquid through a check valve. Positive movement of the piston during the charging phase results in the storage of energy into the springs, which is later used for driving the liquid at constant pressure. Therefore, no external power supply is required during the pumping action.

The proposed design is more power efficient as compared to various membrane-type mechanical and non-mechanical micropumps reported in the literature [1]. The spring-driven actuation eliminates the need for the integration of electrical actuation circuitry into the microfluidic system. In addition, the dispenser provides a continuous flow at constant inlet pressure. Such flow characteristics are particularly important in chemical/bio-chemical analysis systems and fuel cells to reach the reaction equilibrium state. Also, as compared to the non-mechanical micropumps, such as magneto-hydrodynamic pump, and electrokinetic pump, which require certain liquid properties [2], the mechanical actuation scheme proposed here can be used to pump any type of liquid.

Preliminary Results

Figure 2 shows the first concept-testing prototype developed using rapid prototyping process-stereolithography. Two constant force springs (0.37lbs each; Ametek Hunter Products, Sellersville, PA) are used to follow linear motion with the piston. The 1cc capacity bellows is initially charged with water (working liquid). The liquid pressure is monitored at port 1, while the average flow rate at port 2 is controlled at 11µl/min using a micro-metering valve. The results obtained are plotted in Figure 3. The stiction forces acting between the sliding surfaces, such as the piston; and the spring bush, produced pressure variations in the range of 3.9-5.7 psig. A small decrease in the spring force is observed at low extension length of the spring.

However, the preliminary results obtained are encouraging and show that a constant-pressure dispensing unit can be realized using the current design by minimizing the stiction forces and operating at higher extension length of the spring.

Future Work

The stiction forces in the current design would be minimized using bearings and considering alternate materials. Design alternatives will be considered for a comparative study.

Reference:

[1] P. Gravesen, J. Branebjerg, and O. S. Jensen, “Microfluidic-a review”, *Journal of Micromechanics and Microengineering*, Vol. 3, No. 4, pp. 168-182, Dec 1993

[2] A. V. Lemoff and A. P. Lee, “An AC magnetohydrodynamic micropump”, *Sensors and Actuators B*, Vol. 63, No. 3, pp. 178-185, 2000

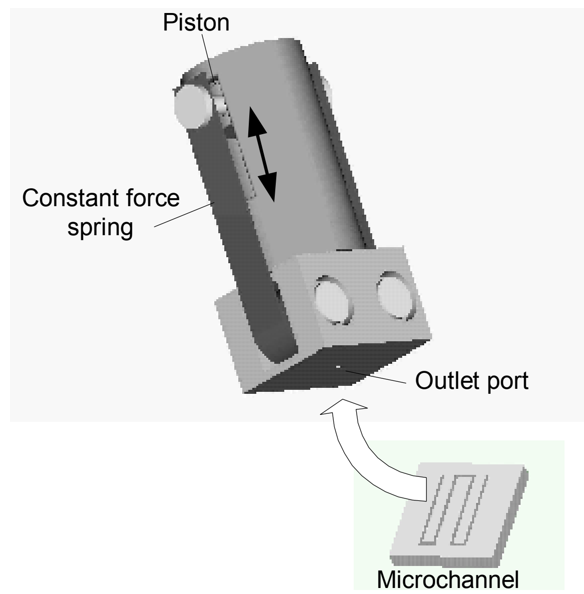

Figure 1. Solid model of liquid dispensing unit

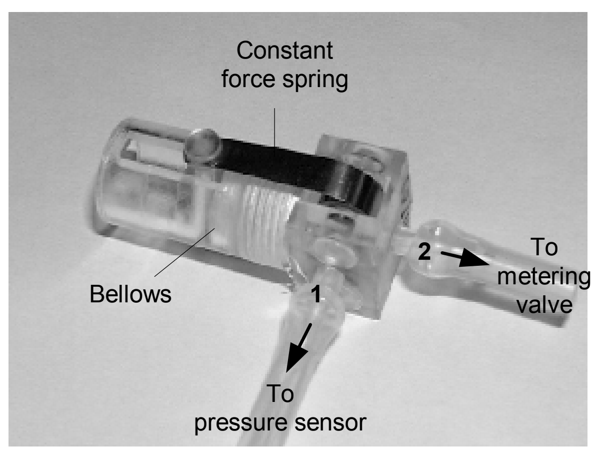

Figure 2. Concept testing prototype

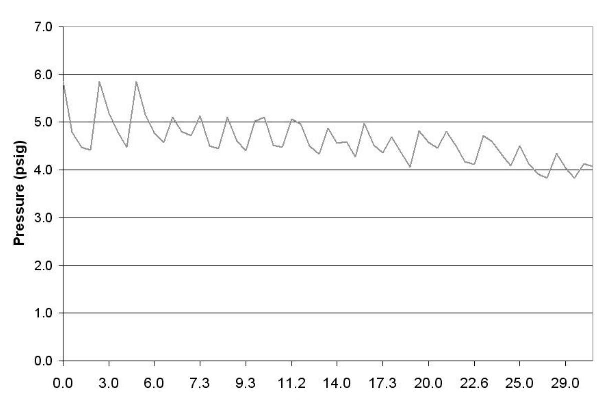

Figure 3. Inlet liquid pressure vs. time for average flow rate of 11µl/min