Vibration and Displacement Testing of the Microvalve Actuator under Air Damping

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This paper report the displacement and vibration testing of the microvalve membrane under air damping. The schematic test setup is shown in the figure 1. The tests were done by using laser vibrometer Polytec OFV 3001S. The Laser is focused to the center of the valve membrane, with the minimum Laser spot size of 40 µm. The Laser vibrometer continuously detects the Laser intensity reflected from the moving membrane. The Laser vibrometer is connected to the PC computer that converts the data to the membrane velocity at instantaneous time. The membrane displacement is obtained by integrating the velocity.

A pulse of voltage is applied to the coils to produce an electromagnetic force that deflects the membrane. The voltage profile is produced by signal generator is applied to the coil and monitored on the oscilloscope. Damping is introduced by applying nitrogen gas to the back of the valve array. Each valve has a through hole so that the nitrogen pressure is varied by pressure regulator with connected pressure sensor.

The purpose of this test is to determine the minimum amount of time required for the valve membrane to move downward and touch the gasket under different nitrogen damping pressure. The schematic and fabrication of the valve is reported in [1]. Valve displacement characteristic under no damping is reported in [2]. Experiments were carried out at different pulse frequencies, voltages, and nitrogen pressures. Tests on the valve membrane with two supporting torsional legs, show that under no external pressure, the valve membrane moves downward at a distance of 10 µm from it normal flat position. The pulse time required for this motion can be as short as 0.5 ms at a voltage of 2.84 V. This corresponds to a power of 1.74 Watts and an energy of 0.86 mJ.

Figure 2 shows the velocity and displacement profile of the valve membrane at a nitrogen pressure of 86 torr = 11.3 kPa. A 3.1 V, 5 ms voltage pulse applied to the coil produced a displacement of 14 µm. This indicates that the valve membrane was previously displaced by 4 µm upward by the nitrogen pressure. In this case the power input to the coil was 2.04 Watts and an energy of 10.2 mJ. Figure 2 shows that after 0.4 ms of the 5 ms pulse was required for the valve membrane to achieve its full deflection, for the rest of the time, 4.6 ms, the valve membrane sits on the gasket.

References:
[1] J.S. Bintoro and P.J. Hesketh, J. Micromechanics and Microengineering, 2004, paper under review
[2] R. Luharuka, S. Ahsan, J. S. Bintoro, Y. H. Berthelot, and P. J. Hesketh, JMEMS, 2004, paper on review

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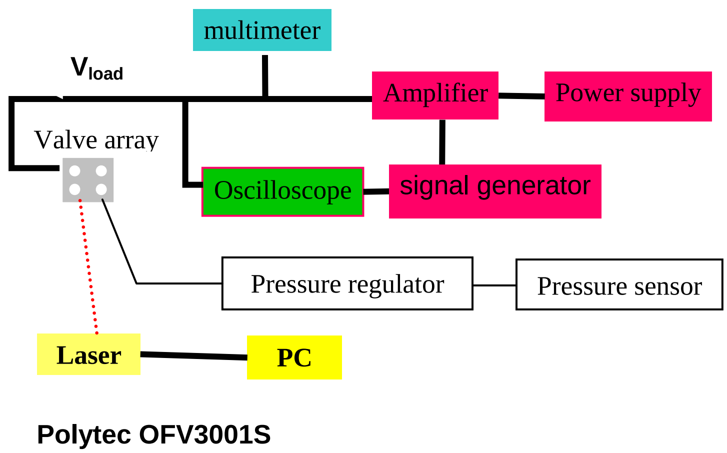
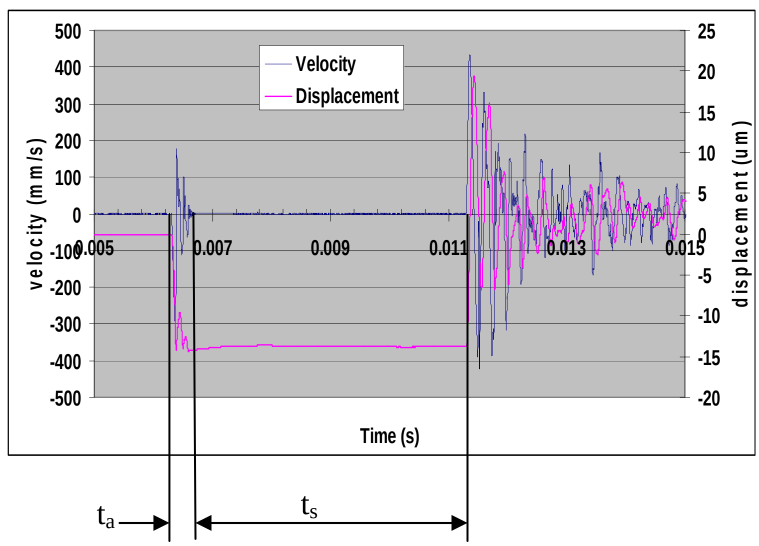


Figure 1
Schematic of the valve displacement and vibration measurement



t_a = actuation time = 0.4 ms
t_s = sitting time = 5 – 0.4 = 4.6 ms

Figure 2
The velocity and displacement profile of valve membrane with nitrogen damping pressure of 11.3 kPa, pulse time 5 ms.