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Research Article

Pressure Measurement of Water Using Integrated Fluidic Circuit

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Abstract

In this paper we measure the pressure of water in the flat container. The length of the flat container is 0.3 m, width is 0.25 m and height is 0.03 m. The volume of the flat container is 2.25×10^{-3} m^3. We use deionized water. We measure the water in the measurement cup. The diameter of the cup is 69 mm and height is 67 mm. The volume of cup is 2.5×10^{-4} m^3. Here, we use digital mass balance. The mass of the empty cup is 32.4 g. The mass of water in the cup is 287.7 g. The mass of water is 255.35 g. The density of water in the cup matches the literature. We take 9 cups of water and transfer them to the flat container. The mass of water in the flat container is 2.29815 kg. The density of water in the flat container matches the literature. The pressure transmitter is integrated with battery, multimeters, electronic ON/OFF switch and electrical wirings. The multimeters are used to measure the voltage of battery and pressure transmitter, respectively. The current of the pressure transmitter is measured using second multimeter. The pressure transmitter is in contact with the water in the flat container. We measure the pressure for three cycles. Each cycle consists of 5 days. Each day we take measurements for 5 to 8 hours with time interval of 1 hour. The readings are taken from human effort. We perform Ansys Fluent simulations to obtain the numerical pressure contour of water along the entire flat container. The experiments provide the pressure of water at a point in the flat container. Our integrated fluidic circuit can find applications in sensors, displays, google maps, air fresheners and medical devices.

INTRODUCTION

The need to understand the direct adhesion between solid liquid from experiments should provide contact properties. The properties we are aware of are pressure, friction, wear and aging. The contact should be surface and interior [1]. Liquids include water, fuel, electrolyte and particulate. It is needed to study for soft matter. Hydrostatics is the branch of engineering that deals with the pressure and density of water in a container [2]. The mass of the water is related to the density of water and volume. The volume is the water filled in the container. The contact of electrical insulators with water in the container provides the current understanding of solids in contact with liquid. They are used in recent air fresheners. The plastics of different shapes in the medium of water are also used for fluid based displays. The properties of the mixture of plastics, solids, insulators, electrical wound insulators with water, electrolyte, purifiers and detergents needs further study. The structure of elements in the plastics needs thorough study. The elements in them in contact with water should be studied. The role of electronics, electrical wound insulators and their elements with and without water should be studied. Further, the properties should be explained for that structure [3]. The atomic orbitals relation with energy should be known from the device. The design of the fluidic based electronics should be the focus towards new age circuits. They can find applications towards next generation fluid based calculators and computers. The shape of the fluidic circuit should provide the diode, logic gate, transistor, displays, processors and computer. For this the solid liquid contact measurements and understanding of properties like density and pressure study are must. The integration should be giving us the integrated fluidic circuits. Recent studies have used membranes in contact with fluids like hydrogen [4]. The adhesive property of membrane and hydrogen are studied. The work focuses on hydrogen-responsive palladium-grapheme composite membranes that illustrate switch of hydrogen response with the membrane. The response function is non-trivial to hydrogen gas seepage. This confirms the structure study of the composite and hydrogen nanoscale architecture visual mapping is needed. They should provide the live detection of the solid fluid interaction to time measurements.

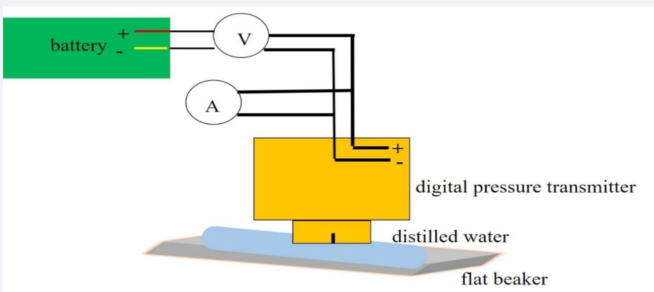

Figure 1 Schematic of the pressure measurement of the water inside the flat container.

The communication circuit should be studied in the future. The pressure of water is typically measured using pressure transmitter. There are two types, manual and automated [5]. The manual pressure transmitter gives the pressure applied from human effort. The global scenario is preparing to understand the relationship of property measurement of liquids, fluids with solid in open surfaces to describe the fuel in equilibrium [6]. The non-equilibrium resulting the transport of the liquid should be the scope of the future work. The interdisciplinary research efforts are ongoing to characterize the element thoroughly. The scope of the use of liquids in contact with solids can find applications in energy, energy storage, fuel, displays, purifiers, water desalination, fresheners, sensors, fluidic electronics, semiconductor and computer [7].

In this paper we introduce a method to determine the pressure of water in a flat container. We measure the pressure using manual approach. We use digital pressure transmitter for this purpose. Here, we build fluidic circuit for the first time. We have battery connected to pressure transmitter. The battery and pressure transmitter are connected to two multimeters. The first multimeter provides the voltage of battery and pressure transmitter. The battery and pressure transmitter are connected in series. The second multimeter gives the current of the pressure transmitter. We use electronic ON/OFF switch. The pressure transmitter is in direct contact with the water. The water is present in a flat container. We use human effort and apply pressure to measure the hydrostatic pressure of water in the flat container. The automated pressure readings with no human intervention should be the scope for the future work. Here, we measure the room temperature using digital temperature sensor. Figure 1 shows the schematic of the integrated fluidic circuit to measure the pressure of water inside the flat container.

The rest of the paper is outlined as follows. Section 2 discusses the experimental section. The theories are given in section 3. The simulations to understand the pressure distribution of water in the flat container are given in section 4. A detailed discussion is provided in section 5. Finally, conclusions are presented in Section 6.

Figure 2 Schematic of the pressure measurement of the water inside the flat container.

EXPERIMENTAL SECTION

The flat container and measurement cup are purchased from Omega glassware, India. The length of the flat container is 0.3 m, width 0.25 m and height are 0.03 m. The volume of the flat container is 0.0023 m^3. The diameter of the cup is 69 mm and its height is 67 mm. The volume of the cup is 2.5×10^{-4} m^3. The deionized water are purchased from Kesari Chemicals, India. The precision mass balance is purchased from Merck, Germany. The digital pressure transmitters are purchased from IPS Automation, India. The battery is purchased from Shah, India. The multimeters are purchased from Mercy electronics, India. The digital vernier caliper and temperature sensor are also purchased from Industry buying, India. The digital micrometer and plastic scale are purchased from Progressive Trade, India. Figure 2 shows the list of instruments.

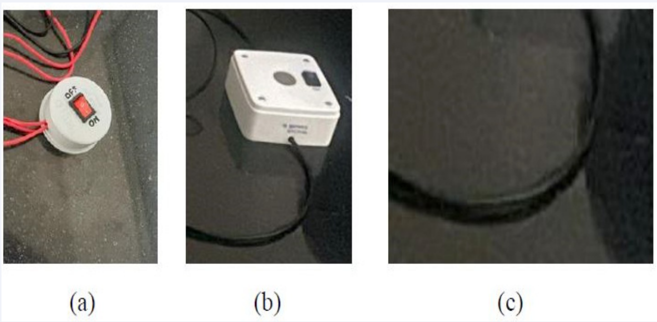

Figure 3 (a) Polyvinyl chloride ON/OFF switch with electrical wirings (b) electrical ON/OFF switch with electrical wirings (c) electrical wirings

Here, we build switch using polyvinyl chloride (PVC) for the first time. The polyvinyl chloride is plastic. Figure 3 (a) shows the polyvinyl chloride ON/OFF switch with electrical wiring. We purchase electrical ON/OFF switch. Figure 3 (b) shows the electrical ON/OFF switch with electrical wiring. The electrical wires are shown in Figure 3 (c).

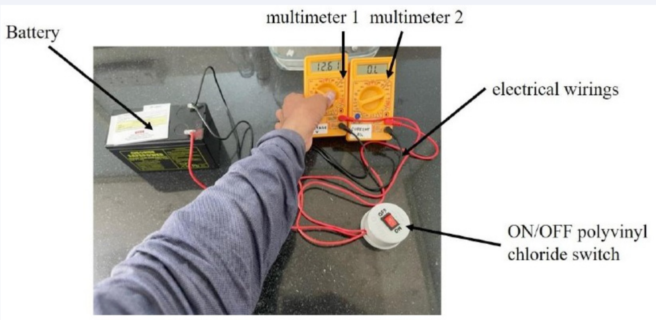

Figure 4 Battery with no load. We obtain voltage. The switch is ON to read the battery voltage. The switch is designed and made using polyvinyl chloride plastics.

Figure 4 shows the battery connected to polyvinyl chloride based ON/OFF switch. In this paper, the mass, volume, density, battery with no load and pressure experiments are obtained from human effort. We connect the battery to two multimeters. There are two electrical wirings between battery, polyvinyl chloride and two multimeters. The battery has no load in the circuit. When the polyvinyl chloride is switched ON we obtain the voltage of the battery. The voltage readings are obtained using one multimeter. We do not obtain the current because there is no load connected to battery. Thus the second multimeter shows no load result (see Figure 4).

Table 1 shows the voltage readings of the battery for 1 hour. The time interval is 10 minutes. The voltages of the battery are 12.62 V for 10 minutes to 60 minutes as shown in Table 1. The voltage of the battery measurements matches the battery voltage purchased from the vendor.

Table 1 Battery readings with no load

Time (minutes)	Battery Voltage (V)
10	12.62
20	12.62
30	12.62
40	12.62
50	12.62
60	12.62

Mass Measurement of Water

Table 2 shows the dimensions of the measurement cup. The diameter of the cup is 69 mm and its height is 67 mm. The volume of the cup is 2.5×10^{-4} m^3.

Table 2 Volume details of the measurement cup

Parameters	Measurement Cup
diameter	69 mm
height	67 mm
volume	2.5×10^{-4} m^3

Table 3 shows the mass of the cup. We measure for 15 s. The time interval is 1 s. The average mass of the cup from the measurement is 32.4 g. The mass of the water in the cup is measured for the same time. The time interval is 1 s. Table 3 shows the mass of water inside the cup. The average mass of the water in the cup is 287.7 g. The mass of water is obtained by subtracting the mass of water in the cup with the mass of empty cup. Table 3 shows the mass of water for the same time. The time interval is 1 s. The average mass of water is 255.35 g. Table 3 shows the mass of water and cup results.

Table 3 Measurements of mass of the cup. Mass of the water in the cup

Time (s)	Mass of Cup (g)	Mass of Water Inside the Cup (g)	Mass of Water (g)	Average Mass of Water (g)
1	32.34	288	255.66	255.35
2	32.25	287	254.75	
3	32.27	288	255.73	
4	32.34	287.73	255.39	
5	32.45	287.6	255.15	
6	32.16	287.9	255.74	
7	32.24	287.6	255.36	
8	32.17	287.6	255.43	
9	32.8	287.9	255.1	
10	32.85	287.6	254.75	
11	32.23	287.46	255.23	
12	32.12	287.6	255.48	
13	32.75	287.45	254.7	
14	32.2	288.7	256.5	
15	32.22	287.5	255.28	

Here we use 9 cups of water. The average mass of water from 9 cups is 2298.15 g. We transfer 2298.15 g of water to the flat container. We did this way. We transfer the water of mass 255.35 g from the measurement cup to the flat container 9 times. Table 4 shows the dimensions of the flat container. The length of the flat container is 0.3 m, width is 0.25 m and its height is 0.03 m. The volume of the cup is 2.25×10^{-3} m^3.

Table 4 Dimensions of the flat container

Parameters	Flat Container
Length	0.3 m
Width	0.25 m
Height	0.03 m
Volume	$2.25 \times 10^{-3}\ m^3$

Density of Water

Next, we calculate the density of water. We obtain the density of deionized water in the cup and flat container. The density of water in the cup is obtained from the average mass of water from Table 3 and cup volume. The density of water matches the literature. The density of water in the flat container is obtained from the mass of water in the flat container and container volume. The mass of water in the flat container is 2298.15g as mentioned earlier. The density of water in the flat container also matches the literature.

THEORY

The hydrostatic pressure of water is given by Eq. (1)

$$P = \rho g H \qquad (1)$$

Where P is the hydrostatic pressure, ρ is the density of water, g is the gravity and H is the height of the water inside the flat container.

The density of water is given by Eq. (2).

$$\rho = \frac{m}{v} \qquad (2)$$

Where m is the mass of water. v is the volume given by Eq. (3).

$$v = LWH \qquad (3)$$

Where L is the length of the flat container, W is the width and H is the height.

NUMERICAL SIMULATIONS

The hydrostatic pressure distribution of water along the entire flat container is given by the partial differential equation (PDE) Eq. (4).

$$\nabla P = \rho g \qquad (4)$$

Where gz is the gravity. We use Ansys Fluent software to simulate the hydrostatic pressure distribution of water along the entire flat container. We use grid spacing of 5 mm. Our results are grid independent.

RESULTS

In this paper we measure the pressure of the water at a point. We measure one point that is at the base of the flat container. Figure 5 shows the pressure obtained from the digital pressure transmitter. We built integrated fluidic circuit to measure the pressure of water for the first time. Figure 5 shows the point where the pressure of water is measured. The integrated fluidic circuit is made up of flat container with water, digital pressure transmitter, electrical ON/OFF switch with electrical wirings, battery and two multimeters.

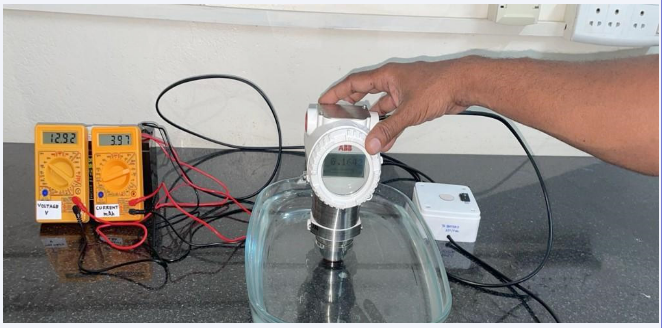

Figure 5 Pressure measurement of water inside the flat container. The pressure transmitter is connected to fluidic circuit

The pressure of water readings are taken from human effort. Here, we take the pressure readings using the following approach. First, we measure the pressure of water for 1 hour. Table 5 shows the readings for the pressure of the water for 1 hour. The time interval is 10 minutes. The average pressure of water is 0.16 kPa. The battery voltage and digital pressure transmitter input voltage from battery are shown in Table 5. The pressure transmitter input current is shown in Table 5. The input current of the pressure transmitter shows the working of the pressure device. We use the digital temperature sensor to measure the room temperature. The temperature is 29.5^{0}C as shown in Table 5.

Secondly, we measure the pressure of water for 1 cycle. In order to realize the pressure readings of water for 1 cycle the following method is used. We perform pressure measurements for 5 days. Each day we measure for 5 to 8 hours. The time interval for each measurement is 1 hour. We repeat for 5 days.

Table 5 Digital pressure measurements of water. Readings for 1 hour. The time interval is 10 minutes.

Time (Minutes)	Battery Voltage (V)	Pressure Transmitter Voltage (V)	Pressure Transmitter Current (mA)	Digital Pressure Transmitter Readings of Water in the Flat Container (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
10	12.92	12.92	3.97	0.1645	0.16	29.5
20	12.92	12.92	3.97	0.1537		
30	12.92	12.92	3.97	0.1681		
40	12.92	12.92	3.97	0.1756		
50	12.92	12.92	3.97	0.1669		
60	12.92	12.92	3.97	0.132		

The room temperature was also measured. The time of readings in each day are recorded. Table 6 to Table 10 shows the pressure readings. We obtain the average pressure of each day and the average pressure for cycle 1 consisting of 5 days. We proceed to take readings using similar procedure for cycle 2 and cycle 3, respectively. The automated pressure measurements and saving them online should be the scope of the future work.

Cycle 1: Pressure readings of water

Table 6 shows the pressure measurement of the water on day 1. The readings are taken from 10 AM to 5 PM. The time interval is 1 hour. We obtain 7 measurements. The average pressure of water is 0.15 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 6. The pressure transmitter inputs current are shown in Table 6. The room temperature is 29.5^{0}C.

Table 7 shows the pressure measurement of the water on day 2. The readings are taken from 12 Noon to 5 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.16 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 7. The pressure transmitter inputs current are shown in Table 7. The room temperature is 32.3^{0}C.

Table 8 shows the pressure measurement of the water on day 3. The readings are taken from 12 Noon to 5 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.16 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 8. The pressure transmitter inputs current are shown in Table 8. The room temperature is 31.4^{0}C.

Table 9 shows the pressure measurement of the water on day 4. The readings are taken from 11 AM to 5 PM. The time interval is 1 hour. We obtain 6 measurements. The average pressure of water is 0.164 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 9. The pressure transmitter inputs current are shown in Table 9. The room temperature is 32.3^{0}C.

Table 6 Pressure measurements of water. Readings for day 1. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Pressure Transmitter Voltage (V)	Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.89	12.89	3.96	0.1428	0.15	29.5
2	12.88	12.88	3.97	0.1538		
3	12.88	12.88	3.96	0.1248		
4	12.89	12.89	3.97	0.158		
5	12.88	12.88	3.97	0.148		
6	12.89	12.89	3.96	0.1518		
7	12.88	12.88	3.96	0.1618		

Day 1: Measurement time from 10.00 AM to 5.00 PM

Table 7 Pressure measurements of water. Readings for day 2. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Pressure Transmitter Voltage (V)	Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.86	12.86	3.97	0.1563	0.16	32.3
2	12.85	12.85	3.97	0.1812		
3	12.85	12.85	3.96	0.1469		
4	12.84	12.84	3.97	0.1749		
5	12.84	12.84	3.97	0.1391		

Day 2: From 12 Noon to 5 PM

Table 8 Pressure measurements of water. Readings for day 3. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.84	12.84	3.97	0.1467	0.16	31.4
2	12.85	12.85	3.96	0.1977		
3	12.83	12.83	3.97	0.141		
4	12.85	12.85	3.96	0.162		
5	12.85	12.85	3.96	0.15		

Day 3: From 12 Noon to 5 PM

Table 9 Pressure measurements of water. Readings for day 4. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.84	12.84	3.97	0.1724	0.164	32.3
2	12.84	12.84	3.96	0.1668		
3	12.83	12.83	3.96	0.1915		
4	12.83	12.83	3.97	0.162		
5	12.84	12.84	3.96	0.134		
6	12.84	12.84	3.97	0.156		

Day 4: From 11 AM to 5 PM

Table 10 Pressure measurements of water. Readings for day 5. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.86	12.86	3.97	0.2172	0.16	32.8
2	12.86	12.86	3.96	0.1372		
3	12.85	12.85	3.97	0.1563		
4	12.83	12.83	3.97	0.1442		
5	12.84	12.84	3.96	0.1542		

Day 5: From 12 Noon to 5 PM

Table 10 shows the pressure measurement of the water on day 5. The readings are taken from 12 Noon to 5 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.16 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 6. The pressure transmitter input current are shown in Table 6. The room temperature is 32.8^{0}C.

Table 11 shows the pressure of water in the flat container from day 1 to day 5. This is for cycle 1. We calculate the average pressure of water for cycle 1. We use the data from day 1 to day 5 to calculate the average pressure of water for cycle 1. The average pressure of water for cycle 1 is 0.16 kPa (see Table 11).

Table 11 Pressure measurements of water from day 1 to day 5. The length of cycle 1 are 5 days. We obtain the average pressure of water for cycle 1.

Cycle 1	Pressure (kPa)	Average Pressure (kPa)
Day 1	0.15	0.16
Day 2	0.16	
Day 3	0.16	
Day 4	0.164	
Day 5	0.16	

Cycle 2: Pressure readings of water

Table 12 shows the pressure measurement of the water on day 1. The readings are taken from 12 Noon to 5 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.153 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 12. The pressure transmitter inputs current are shown in Table 12. The room temperature is 34^{0}C.

Table 13 shows the pressure measurement of the water on day 2. The readings are taken from 8 AM to 1 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.16 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 13. The

Table 12 Pressure measurements of water. Readings for second cycle day 1. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.85	12.85	3.96	0.1197	0.153	34
2	12.84	12.84	3.97	0.1563		
3	12.82	12.82	3.97	0.1593		
4	12.83	12.83	3.96	0.1692		
5	12.82	12.82	3.97	0.1607		

Second Cycle day 1: Measurement time from 12 Noon to 5 PM pressure transmitter input current are shown in Table 13. The room temperature is 32^{0}C.

Table 14 shows the pressure measurement of the water on day 3. The readings are taken from 9 AM to 5 PM. The time interval is 1 hour. We obtain 8 measurements. The average pressure of water is 0.156 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 14. The pressure transmitter inputs current are shown in Table 14. The room temperature is 33.6^{0}C.

Table 15 shows the pressure measurement of the water on day 4. The readings are taken from 8 AM to 1 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.16 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 15. The pressure transmitter inputs current are shown in Table 15. The room temperature is 33.8^{0}C.

Table 16 shows the pressure measurement of the water on day 5. The readings are taken from 8 AM to 3 PM. The time interval is 1 hour. We obtain 7 measurements. The average pressure of water is 0.148 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 16. The pressure transmitter inputs current are shown in Table 16. The room temperature is 34.1 ∘ C.

Table 17 shows the pressure of water in the flat container from day 1 to day 5. This is for cycle 2. We calculate the average pressure of water for cycle 2. We use the data from day 1 to day 5 to calculate the average pressure of water for cycle 2. The average pressure of water for cycle 2 is 0.155 kPa (see Table 17).

Table 13 Pressure measurements of water. Readings for second cycle day 2. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.82	12.82	3.97	0.1326	0.16	32
2	12.83	12.83	3.96	0.1593		
3	12.81	12.81	3.97	0.1642		
4	12.82	12.82	3.96	0.1845		
5	12.82	12.82	3.96	0.155		

Second Cycle day 2: from 8 AM to 1 PM

Table 14 Pressure measurements of water. Readings for second cycle day 3. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.83	12.83	3.96	0.1763	0.156	33.6
2	12.82	12.82	3.97	0.1602		
3	12.81	12.81	3.96	0.182		
4	12.81	12.81	3.97	0.1354		
5	12.81	12.81	3.96	0.1273		
6	12.83	12.83	3.96	0.1424		
7	12.82	12.82	3.97	0.1568		
8	12.82	12.82	3.96	0.168		

Second Cycle day 3: from 9 AM to 5 PM

Table 15 Pressure measurements of water. Readings for second cycle day 4. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.83	12.83	3.96	0.2014	0.16	33.8
2	12.82	12.82	3.97	0.1753		
3	12.81	12.81	3.97	0.1432		
4	12.81	12.81	3.96	0.1352		
5	12.81	12.81	3.96	0.142		

Second Cycle day 4: from 8 AM to 1 PM

Table 16 Pressure measurements of water. Readings for second cycle day 5. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.83	12.83	3.96	0.1135	0.148	34.1
2	12.84	12.84	3.97	0.1504		
3	12.82	12.82	3.97	0.1235		
4	12.79	12.79	3.97	0.1535		
5	12.8	12.8	3.96	0.1648		
6	12.8	12.8	3.97	0.1638		
7	12.82	12.82	3.96	0.1648		

Second Cycle day 5: from 8 AM to 3 PM

Table 17 Pressure measurements of water from day 1 to day 5. The length of cycle 2 is 5 days. We obtain the average pressure of water for cycle 2.

Cycle 1	Pressure (kPa)	Average pressure (kPa)
Day 1	0.153	0.155
Day 2	0.16	
Day 3	0.156	
Day 4	0.16	
Day 5	0.148	

Cycle 3: Pressure readings of water

Table 18 shows the pressure measurement of the water on day 1. The readings are taken from 12 Noon to 5 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.156 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 18. The pressure transmitter inputs current are shown in Table 18. The room temperature is 32 ∘ C.

Table 19 shows the pressure measurement of the water on day 2. The readings are taken from 11 AM to 4 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.156 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 19. The pressure transmitter inputs current are shown in Table 19. The room temperature is 31.3 ∘ C.

Table 20 shows the pressure measurement of the water on day 3. The readings are taken from 12 Noon to 5 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.167 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 20. The pressure transmitter inputs current are shown in Table 20. The room temperature is 30.8 ∘ C.

Table 21 shows the pressure measurement of the water on day 4. The readings are taken from 11 AM to 4 PM. The time interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.142 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 21. The pressure transmitter inputs current are shown in Table 21. The room temperature is 31.2 ∘ C.

Table 22 shows the pressure measurement of the water on day 5. The readings are taken from 12 Noon to 5 PM. The time

Table 18 Pressure measurements of water. Readings for third cycle day 1. The time interval is 1hr

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter voltage (V)	Digital Pressure Transmitter current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.77	12.77	3.96	0.1397	0.156	32
2	12.76	12.76	3.97	0.1468		
3	12.77	12.77	3.97	0.1638		
4	12.75	12.75	3.96	0.1598		
5	12.76	12.76	3.97	0.1698		

Third Cycle day 1: from 12 Noon to 5 PM

Table 19 Pressure measurements of water. Readings for third cycle day 2. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (^{0}C)
1	12.76	12.76	3.96	0.1487	0.156	31.3
2	12.77	12.77	3.97	0.1598		
3	12.76	12.76	3.97	0.1764		
4	12.74	12.74	3.96	0.1742		
5	12.75	12.75	3.97	0.1215		

Third Cycle day 2: from 11 AM to 4 PM

Table 20 Pressure measurements of water. Readings for third cycle day 3. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (⁰C)
1	12.76	12.76	3.96	0.1508	0.167	30.8
2	12.75	12.75	3.96	0.1763		
3	12.76	12.76	3.97	0.1805		
4	12.74	12.74	3.96	0.1817		
5	12.75	12.75	3.97	0.1427		

Third Cycle day 3: from 12 Noon to 5 PM

Table 21 Pressure measurements of water. Readings for third cycle day 4. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (⁰C)
1	12.76	12.76	3.96	0.1284	0.142	31.2
2	12.77	12.77	3.97	0.1327		
3	12.76	12.76	3.96	0.1458		
4	12.75	12.75	3.97	0.1564		
5	12.78	12.78	3.96	0.1505		

Third Cycle day 4: from 11 AM to 4 PM

Table 22 Pressure measurements of water. Readings for third cycle day 5. The time interval is 1 hour.

Time (h)	Battery Voltage (V)	Digital Pressure Transmitter Voltage (V)	Digital Pressure Transmitter Current (mA)	Pressure (kPa)	Average Pressure (kPa)	Room Temperature (⁰C)
1	12.76	12.76	3.96	0.1172	0.142	31.8
2	12.77	12.77	3.97	0.1676		
3	12.76	12.76	3.96	0.1548		
4	12.75	12.75	3.97	0.1438		
5	12.78	12.78	3.96	0.1284		

Third Cycle day 5: from 12 Noon to 5 PM

interval is 1 hour. We obtain 5 measurements. The average pressure of water is 0.142 kPa. The battery voltage and pressure transmitter input voltage from battery are shown in Table 22. The pressure transmitter inputs current are shown in Table 22. The room temperature is 31.8⁰C.

Table 23 Pressure measurements of water from day 1 to day 5. The length of cycle 3 are 5 days. We obtain the average pressure of water for cycle 3.

Cycle 1	Pressure (kPa)	Average pressure (kPa)
Day 1	0.153	0.153
Day 2	0.16	
Day 3	0.156	
Day 4	0.16	
Day 5	0.148	

Table 23 shows the pressure of water in the flat container from day 1 to day 5. This is for cycle 3. We calculate the average pressure of water for cycle 3. We use the data from day 1 to day 5 to calculate the average pressure of water for cycle 3. The average pressure of water for cycle 3 is 0.153 kPa (see Table 23).

Table 24 shows the pressure for cycle 1, cycle 2 and cycle 3, respectively. The pressure readings are discussed earlier.

Figure 6 shows the pressure of water for the cycle 1, cycle 2 and cycle 3. The method to note down the pressure of water is elaborately discussed. The manual pressure reading resulted in small decrease in pressure of water across the three cycles.

Table 24 Average pressure of water from three cycles.

Cycle 1	Average pressure (kPa)
Day 1	0.16
Day 2	0.155
Day 3	0.153

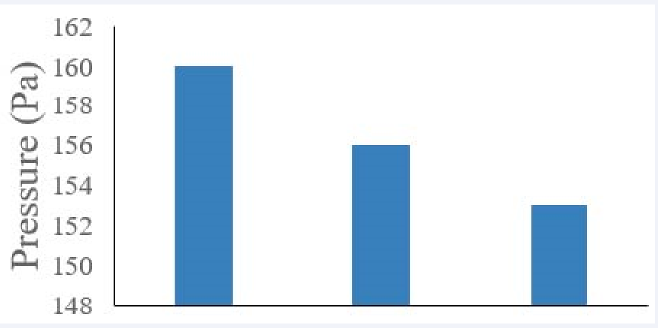

Figure 6 Pressure of water for cycle 1, cycle 2 and cycle 3.

Figure 7 shows the Ansys Fluent results to obtain the numerical pressure distribution of water along the entire flat container. In experiments we obtain the pressure of water at a given point on the flat container. Figure 5 shows the point where the pressure of water is measured. The numerical simulations provide the pressure contour of water along the entire container.

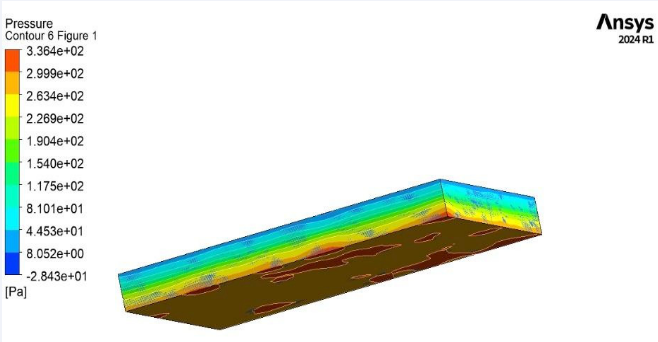

Figure 7 Pressure contour of water in the flat container

CONCLUSION

To conclude we build integrated fluidic circuit for the first time. We measure the pressure of water using our device. We measure the voltage of the battery for no load. We measure mass of water in the measurement cup. We use digital temperature sensor to measure the room temperature. We fabricate polyvinyl chloride ON/OFF switch. We measure the pressure of water for three cycles. The integrated fluidic circuit can find applications in fluid displays (FD), sensors, air fresheners, google maps, soft robotics, medical devices, fluidic computing, fluidic electronics and precision manufacturing of objects.

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AUTHOR CONTRIBUTIONS

Nandigana V. R. Vishal: Conceptualization, Data curation, Formal analysis, investigation, methodology, resources, software, supervision, validation, visualization, writing – original draft, writing – review and editing.

K. Srinivasa Reddy: Conceptualization, Data curation, Formal analysis, investigation, methodology, resources, software, supervision, visualization, writing – review and editing.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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