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Design and Development of a Level Sensor

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***Abstract*— Water is one of the most essential nature's gifts to the manhood and without water no one can imagine their lives. Now man recognized the water significance, particularly where water is not easily available [1]. Now this is being achieved in an appropriate manner in city areas where the use of water is more than its availability [2]. One of the inspiration is to organize computing techniques in creating a barrier to wastage in order to, not only provide more economic gains and energy saving, but also helps the environment and water cycle which in turn guarantees that we save water for our future [3]. There are several problems of electricity in rural area. Also the small towns are incapable to use electricity based level sensors in small industries or domestic tanks. This paper describes the design and implementation of water level sensor prototype without power supply. The sensor consists of low cost materials. Hence sensor is cost effective, reliable and could be made easily available in rural area.**

Keywords— Instrumentation, Measurement, Diaphragm, Water Level Measurement.

I. Introduction

In India, the major challenges in agricultural and industrial water system are water scarcity and wastage of water [3]. The irrigation, land areas close to dam receives abnormal water supply as dam usually releases water during night time. The farmers are not available during night time to physically control this incoming water through canals and sub-canal. This results in water overflow in sub-canals and trenches leading to wastage of water and disturbance in economic water balance cycle. Also, due to crop variation and absence of storage tanks within the system, this improper canal water released create un-necessary outflow losses in the water transportation system. The traditional irrigation area system mostly uses the wireless medium to control the water level, divert the rain water during rainfall. It carries the complex wiring, and the line can be easily damaged [1-7].

In this proposed work, the wireless sensor is used in the proposed tank. A diaphragm is used as a pressure sensor. This is highly cost effective, enhances the system's durability and performance- wastage of water avoided, thereby helping in balancing the water flow. Also will overcome the overflow of water in agriculture and domestic area and will preserve the water for future use. Measuring the water level without power supply is the key of the project. This sensor involves the pressure gauge which measures the water pressure and indicate the corresponding water level.

This paper is organized as follows. First, the overview of sensor design is explained, followed by an applied methodology section and then construction and working of sensor. The final section embodies results and conclusion.

II. Overview of Sensor Design

This section includes a brief overview of all the components used in the design. Fig. 1 narrates the block diagram of the sensor design in brief.

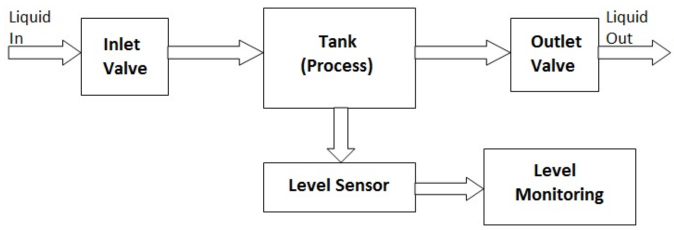

Fig. 1: Block Diagram

Principle of Operation

Following elements are used to achieve desired functionality.

Diaphragm

A diaphragm pressure gauge is a device that uses a diaphragm with a known pressure to measure pressure in a fluid. It has several different uses, such as monitoring the pressure of a canister of gas, measuring atmospheric pressure or recording the strength of the vacuum in a vacuum pump [5].

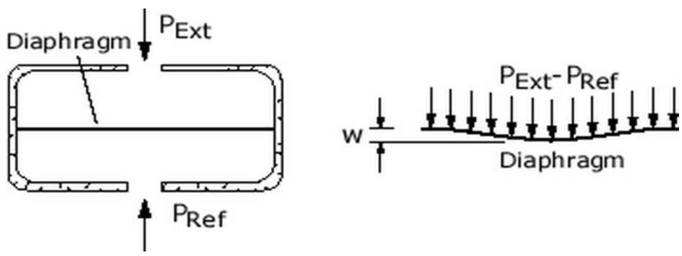

Fig. 2: Basic Principle of Diaphragm

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The diaphragm has a flexible membrane with two sides. One side is an enclosed capsule containing air or some other fluid at a predetermined pressure. The other side can be left open to the air or screwed into whatever system the gauge is meant to measure. The diaphragm also attaches to some sort of meter, which shows how high pressure is to be detected.

A fluid in contact with a flexible membrane pushes on that membrane, bending it. The pressure is a measure of how hard it pushes. When the outside pressure is low, the reference pressure bends the membrane out. As the outside pressure increases, it pushes back on the membrane, bending it back the other way. By measuring how far the membrane bends, the gauge can detect the outside pressure which is measuring pressure.

There are various different ways to measure the pressure from a dynamic pressure gauge. One of the simplest ones is to attach a needle to the gauge. When the pressure increases, it pushes on the needle, moving it up and down along a dial which indicates the pressure. Another way is to use an electric resistance strain gauge. An electric resistance strain gauge uses an elongated strip of an electric resistor, a device that resists the flow of electricity. The resistor is attached to the diaphragm. As the diaphragm bends, it stretches out the resistor, increasing the resistance. An electric current has been running through the resistor. As the diaphragm bends more and resistance increases the current drops more. The gauge can be determine the diaphragm bending by measuring an electric current, and thus, measures the pressure of outside air which is created.

A. Working Principle

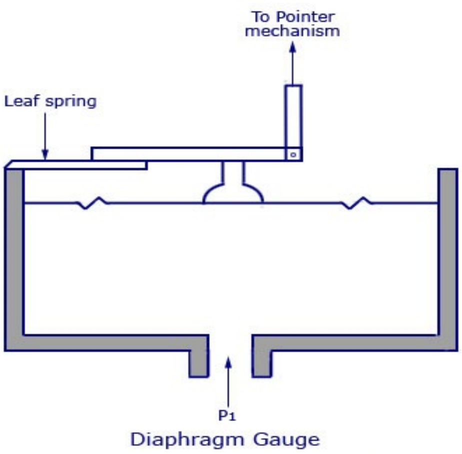

Fig. 3: Working of Diaphragm

The diagram of diaphragm pressure gauge is shown in Fig. 3. When a force acts against a thin stretched diaphragm, it causes a deflection of the diaphragm with its center deflecting the utmost.

Manometer

A device used to measure the pressure at any point in a fluid. Manometers are also used to measure the differential pressure, absolute pressure and gauge pressure.

U-Tube Manometer

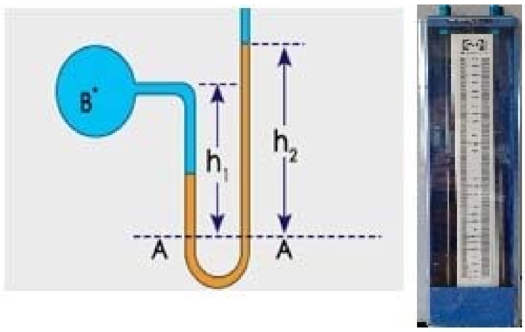

Fig. 4: U-Tube Manometer

It consists of a glass tube bend like the letter ’U’. In this type of manometer balancing the column of same or other liquid. One end of the U-tube is attached to the point where pressure is to be measured, whereas the other end is open to atmospheric pressure. The pressure at point B can be calculated as follows:

$$P=\rho 2gh2-\rho 1gh1$$

Where,

ρ2 = Density of heavy liquid,
h2 = Height of heavy liquid above reference line,
ρ1 = Density of light liquid,
h1 = Height of light liquid above reference line.
g = Acceleration due to gravity = 980 cm sec^{-2}.

- Manometer Specifications:
  - i. Range = 0-300 mm Hg
  - ii. Minimum Division = 1 mm Hg
  - iii. Liquid Filled = Mercury
  - iv. Make = NEESHIONICS

Water Tank (Bucket)

Fig. 5: Bucket (as a Water Tank)

Fig. 5 shows the bucket which is used as a small tank for the testing of the sensor.

- Dimensions of Bucket:
  - i. Height = 0.4 m
  - ii. Diameter = 0.3 m
  - iii. Water capacity = 17 Liter

III. APPLIED METHODOLOGY

A. *Working Principle:*

When the uniform pressure is applied on diaphragm then the deformation of the diaphragm takes place. This deformation is measured on U-Tube manometer which indicates this differential pressure as the level of the water in the tank.

B. *Material Selection:*

- Solid plastic for sensor body
- Thin rubber as a diaphragm

1. Dimensions of Sensor:
   - i. Height = 0.015 m
   - ii. Radius = 0.024 m
   - iii. Volume = 0.000027 m^3

2. Diaphragm Size:

   Thickness of Diaphragm= 0.001 m

IV. CONSTRUCTION AND WORKING OF SENSOR

Fig. 6: Sensor Body Structure

Fig. 6 describes the sensor body structure. Its upper part is open for diaphragm fitting and its bottom surface is closed. There is one hole (0.004 m diameter) to attach the capillary tube.

Fig. 7: Diaphragm Sensor

Fig. 7 shows the diaphragm structure with sensor body, capillary connection and manometer. The sensor consists of sensor body (Material: Solid Plastic) and thin rubber (as a diaphragm). The diaphragm (thin rubber) is fixed on the solid plastic body. The sensor body is hollowed in between. When the sensor is kept under water pressure, it gives change in shape of the diaphragm and this change is obtained in the form of differential pressure. This sensor is further attached with manometer and which gives the indication of water pressure corresponding to the water level in tank.

Fig. 8: Sensor under Water Pressure

As shown in Fig. 8, the sensor is kept inside the bucket (water tank) filled with water. The manometer is having two ends as it measures differential pressure. One end of the manometer is connected to sensor by using capillary tube and the other end is kept open to atmosphere. Therefore the manometer shows the difference in atmospheric pressure and water pressure. When water is in the process of getting filled inside the bucket (as a Tank), the water pressure acts on the diaphragm (sensor) slowly and it gives the corresponding change in pressure with respect to the change in water level.

V. RESULTS

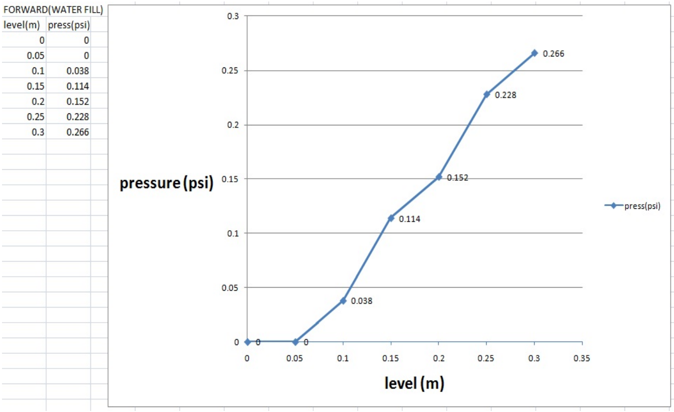

Fig. 9: Pressure Vs Level (Forward Case)

Fig. 9 is a plot of pressure (psi) against level (m). The sensor gives change in level when we gradually increase the water inside the tank and manometer shows result in a change in pressure. Therefore, Fig. 9 represents the linear graph for forward case and which is the characteristic of the sensor.

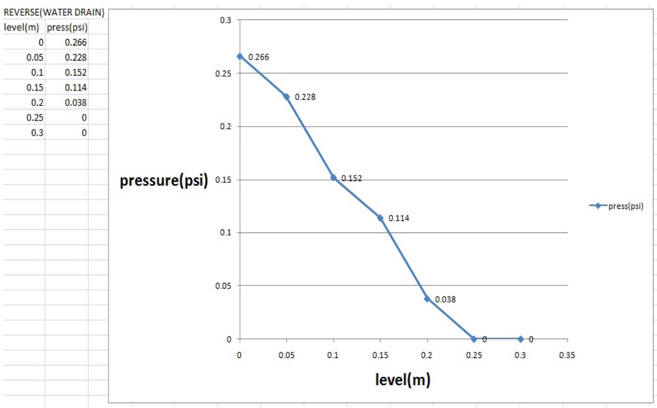

Fig. 10: Pressure Vs Level (Reverse Case)

Fig. 10 is a plot of pressure (psi) against level (m). When the water drains from a bucket (tank), the pressure on the sensor decreases as seen from the graph in Fig. 10.

VI. CONCLUSION

The sensor gives a good linearity and accuracy without electricity. Most of the level measurement techniques are complex and require skill in handling. This paper provides a sensor which reduces the complexity. Also an unskilled person can easily handle and use this level sensor. The rural area people can also use this type of sensor for domestic water tanks which is available with low cost and without electricity.

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