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AUTOMATIC MEASUREMENT AND ALARMING SYSTEM FOR FERROFLUID BASED PRESSURE SENSOR

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Abstract: *Differential pressure measurement is very important. A non contacting automatic pressure measurement and alarming system based on, the ferrofluid based pressure sensor is discussed. The ferrofluid is used as a seal or isolating material as well as pressure data indicator element. The basic sensor is an elastic capsule element. The raspberry pi is used to take care of all the electronic components and the software.*

Keywords: *Ferrofluid, Pressure sensor, Diaphragm capsule, Raspberry Pi*.

I. INTRODUCTION

The pressure is a very important parameter in any industry. The pressure affects the quality of the process, the functioning of the equipment, safety of the instrument and the final product. It is required to be measured accurately and precisely. Many elastic type pressure sensors are touched and a ferrofluid based sensor is described[1].

A magnetic fluid is usually two phase and three component system consisting of solid magnetic particles or Ferro magnetic particles dispersed in a suitable carrier liquid (Figure 1). An appropriate surfactant is coated on each particle to prevent agglomeration and sedimentation. Number density of the particles is of the order of 10^{18} to 10^{23} per ml, and since each particle is single domain, it behaves like a single tiny magnet[2-3,6].

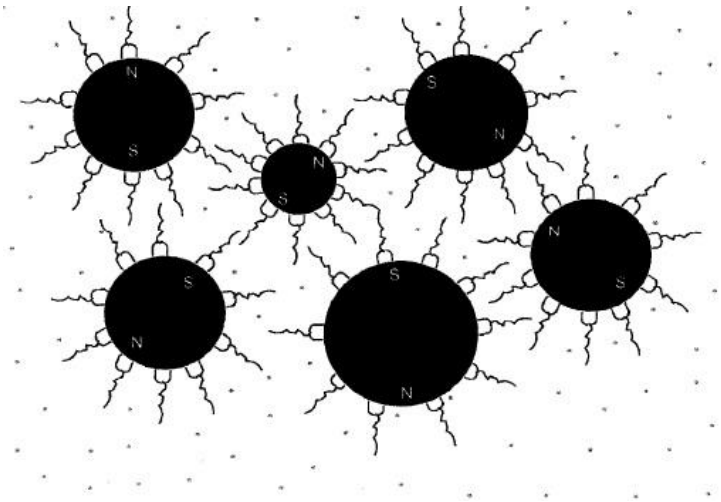

Figure 1- Ferrofluid - Magnetic fluid Components

Naturally such a fluid has property like soft magnetic core as well as sufficient fluidity. Using distinguished properties of the magnetic fluid makes it best choice for many applications. The properties like fluidity and better permeability of the ferrofluid, compared to air is used in the primary device like magnetic fluid material based target disk type fluid flow sensor[3]. Applications of these materials (fluid) are still increasing in numbers as well as in different fields since their inception. It is used in medical field as well, recent application in medical field in implantable port is suggested[4]. The special application of ferrofluid as a solenoid valve is described[5]. Many diversify applications in the field of mechanical and electrical engineering and in medical field are discuced [6].

The raspberry pi is a very powerful device called as minicomputer on board. It has many essential facility available onboard like 4× ARM Cortex-A53, 1.2GHz,Broadcom VideoCore IV, 1GB LPDDR2 (900 MHz) RAM, 10/100 Ethernet, 2.4GHz 802.11n wireless, Bluetooth 4.1 Classic, Bluetooth Low Energy. microSD card slot. The complete electronic and software part is taken care by Raspberry pi.

II. SYSTEM CONCEPT

The pressure sensor is made with the convex capsule diaphragm as shown in the figure 2.

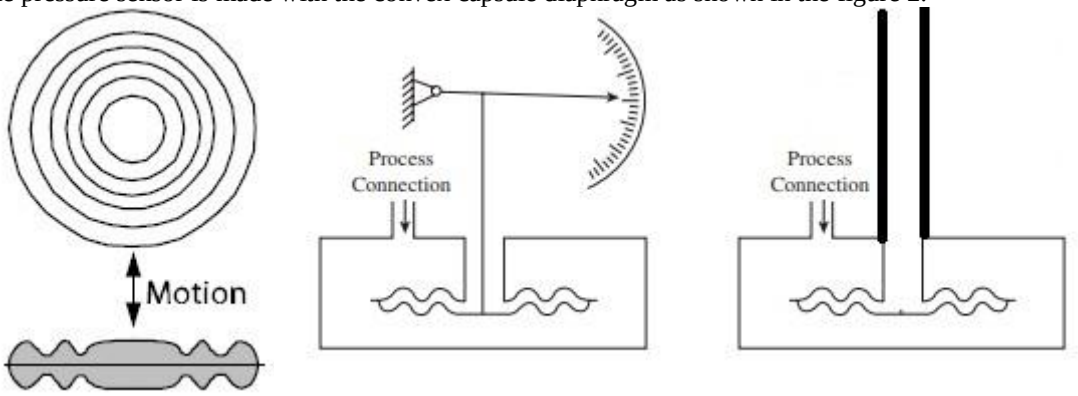

Figure 2 Convex diaphragm capsule B. Nested capsule C. with capillary

The nested capsule made of a convex and a concave diaphragm with the process pressure acting on the outside of the capsule rather than on the inside, makes it possible to have high overpressures tolerance with the nested capsule[7]. The shape can be modified as per the convenience. The range of this element is a function of the materials of construction, capsule diameter, and the particular design[7]. Mechanical linkages are removed and the ferrofluid is field in the capsule. The filled fluid can be different than the ferrofluid, if the temperature requirement is very high. In case like this, the felled fluid density must be higher than the ferrofluid. Ferrofluid will perform the role of the seal. A capillary is connected with the capsule. The capillary is made of the glass to make it possible to see through. The figure 2 B and figure 2C show the capillary and the capsule. The second end of the capillary is kept open to atmosphere, to make it possible to measure the gauge pressure. The system measures the differential pressure, but as the second end is open to atmosphere it gives gauge pressure. The ferrofluid is used as a seal as well as the indicating component. If it is open, ferrofluid is in contact with the air. The ferrofluid will work as a seal and will prevent the fluid inside the capsule to come in the direct contact with the other side fluid in the capillary. The schematic diagram of the sensor part is shown in the figure 2C. The mechanical linkages can be removed so the wear and tear of these components and maintenance are eliminated.

The camera is to be placed in front of the glass capillary. The camera will capture the image of the glass capillary and this image will be read by the raspberry pi through the camera module. The raspberry pi will process the image and will infer the pressure value data, in line with the control room computer. The software takes care of the processing the image and the actuating the alarm signals and further controlling signals. The Complete schematic diagram is shown in the figure 3.

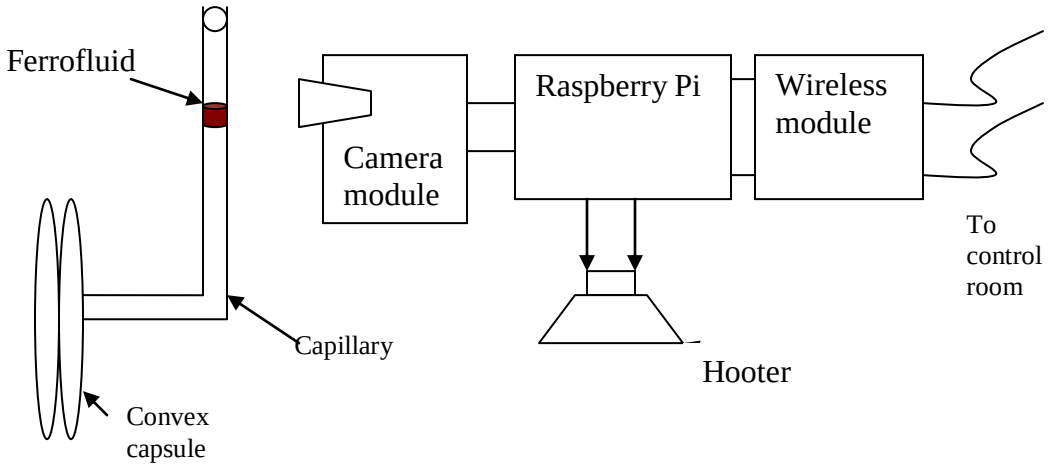

Figure 3 Schematic diagram of the system

There are some very important factors affecting the performance of the complete device, like the distance between the camera and the glass capillary, effective length of the capillary and required sampling rate. As the density of the ferrofluid is lower than the fluid in the capsule, it remains floating on the fluid inside the capillary.

III. EXPERIMENTAL SETUP

We need sensor, Raspberry Pi, camera, camera module to connect it to Raspberry pi, wireless module, display, speaker. The proposed experimental setup is shown in the figure 4.

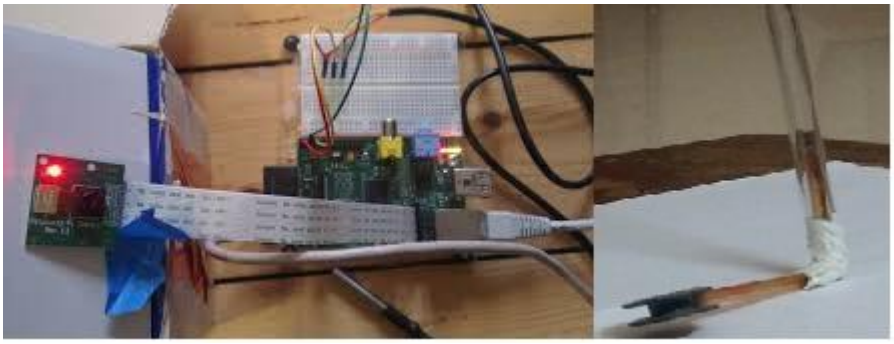

Figure 4 Experimental setup (a) Electronic system (b) Sensor

The level of the ferrofluid in the capillary is to be captured by a camera with the high resolution. The image is processed by the raspberry pi and final result is to be sent to the display as well as in the control room. The camera is used to capture the image of the pressure sensor. The camera module has capability to interface camera with the raspberry pi. The pi compares the image uses lookup table and sends final pressure data to control room by wireless module or Ethernet.

Though there are many options to write software, the software is to be prepared in the python environment. It can be developed using C++ as well. The standard image of the ferrofluid in the glass capillary is captured and stored in the memory as a reference data. The main program compares the image and find out the difference between standard and the latest captured image. The difference is to be compared with the lookup table and the present pressure level data is inferred.

The most important point to be considered is the calibration. The standard image is identified as 1 atmosphere pressure. To calibrate, different known pressure signals are to be applied and the images are captured. These images are used to calculate the difference with the standard image and the values are stored as a lookup table. The alarms can be set by the control room. As the pressure data cross the set alarm limit, the Raspberry pi will trigger the alarm and the speaker, and simultaneously sends the alarm signal to the control room. If the camera and the glass capillary are fixed at their respective positions, no need to compensate for the drift in distance between the glass capillary and the camera. If the distance is variable, ultra sound distance sensor module can be used to calculate the compensating factor. It is required to compensate for the distance drift.

IV. CONCLUSION

The ferrofluid can performs dual role of seal between the fluids on both side of the pressure taps and the indicator element very precisely. The raspberry pi is excellent solution for different tasks like interfacing with different input output devices like camera, speaker display etc, as well as can handle the image processing, data manipulation. The complete system is very cost effective.

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