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DESIGN AND IMPLEMENTATION OF REAL-TIME FLOW MEASUREMENT SYSTEM USING HALL PROBE SENSOR

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Abstract.A rotameter is a flow rate measuring equipment with a changeable area that is used to monitor volumetric flow of liquids and gases. The usage of a unique type of transducer for distant indication is a disadvantage in this case.. The float's components include a thin circular permanent magnet and a Hall probe sensor, which are mounted outside the rotameter tube. A signal conditioner converts (or amplifies) the Hall probe sensor output to generate a 1–5 V dc signal. To illustrate how the system works, a theoretical equation has been developed. The system's performance was put to the test, and the results were positive.

INTRODUCTION

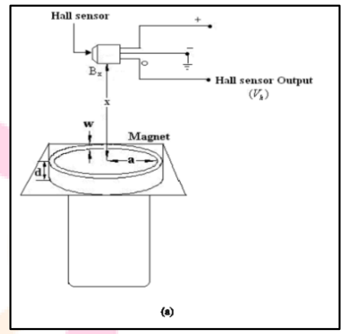
Flow rate measurement in pipeline are the most important process in all industry.The flow measurement is majorly depends on the transducer. Their are different kind of types depending upon the use and the transducer.The orifice type flow meter is used to measure the rate of flow of Liquid or Gas, especially Steam, using the Differential Pressure Measurement.the orifice plate is used for the restriction in the direction of the fluid flow. Therefore the restriction process we also called Orifice Plate. The restriction results in pressure drops in the flow of fluid. The drop in pressure is the rate of flowing fluid or the average velocity of the fluid. The orifice Plate based on the principle of Bernoulli's theorem and that is the sum of all the energy at a point is equal to the sum of all the energy at point 2. Vortex flow meters measure velocity of fluid by the principle von Kármán effect, which states that when the fluid flow passes by a bluff body, a repeating pattern of swirling vortices is generated.Industry has also embraced the development of smart and intelligent flow metres such as coriolis mass flow metres, multi variable flow metres, and microprocessor-based flow metres. A thermal or anemometric type flow metre is similar to a coriolis flow metre in that it measures mass flow. It works on the premise of heat transfer from a hot surface of a sensing device, such as a hot wire resistance or a diode junction, to a moving fluid. It evaluated the performance of two distinct types of insertion flow metres, namely the magnetic flow metre and the turbine flow metre, and found that the magnetic flow metre has the promised accuracy across the flow range, but the other only has the claimed accuracy in the higher range.It investigated the impact of pressure on the performance of a coriolis mass flow metre and discovered that fluid pressure had an impact on the meter's accuracy. We developed a modified straight tube coriolis flow metre with a driving frequency of 750Hz that has a shortened delay time and an ultra quick response REAL-TIME FLOW MEASUREMENT SYSTEM 5593. We've demonstrated a new mass flow rate measurement approach.

METHOD OF APPROACH

Rotameter is a variable area type flowmeter and use to measure the flow.The tube consists of float,which is a solid inverted conical object of density greater than the fluid.Three forces are obtained when a fluid flows throught the pipe and the float acquire an equilibrium position an equilibrium position.The three forces are

- Downward gravitational force
- upward buoyant force
- upward drag force

Assume the float of rotameter is attached to the permanent magnets, that help the magnet to move upwards when the flow rate of fluid increases . Hall sensor is placed outside the rotameter and it helps to measure the variation of magnetic field intensity .The gauss meter's Hall sensor is positioned at an axial point 'P,' with its surface perpendicular to the ring magnet's axis 'OP,' along which its magnetic field acts. The experiment employed a ring magnet with an outer diameter of 53 mm, an inner diameter of 24 mm, and a thickness of 10 mm. A scale is used to measure the axial distance 'OP' of this Hall sensor from the centre 'O' of the top surface of the ring magnet, and a digital gauss metre is used to measure the axial magnetic field. The static characteristic of a ring magnet is depicted as a graph of magnetic field (B) vs axial distance (x). A ring magnet's axial magnetic field (B) almost follows an inverse relationship.



(a)

$$Bx \approx K1\ x\ 2 \quad \ldots\ldots(1)$$

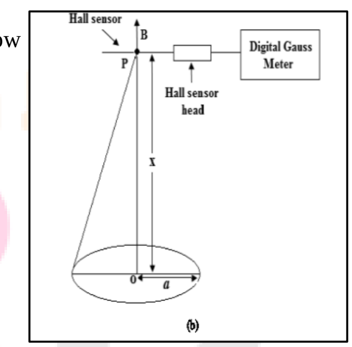
Let Q be the flow rate through the pipeline, and h be the associated float height. We know that flow rate is proportional to float height because of the rotameter principle. Hence ,

$$Q = K2h \quad \ldots\ldots.\ (2)$$

where $K2$ is a constant.

Now the distance of the Hall probe from the float magnet is

$$x = H - h \quad \ldots.\ (3)$$



(b)

H is the distance of the Hall sensor from the float surface at its minimum position at no flow. Hence, from equations (1) and (3) we have

$$Bx = K1\ x\ 2 = K1\ (H - h)\ 2 \quad \ldots..\ (4)$$

Now the Hall voltage Vh of the Hall sensor is proportional to Bx if the current passing through the sensor be kept constant. Hence, we have the following equation.

$$Vh = K3Bx \quad \ldots\ldots(5)$$

where K3 is the constant of proportionality.

From equations *(2), (4) and (5)* we have,

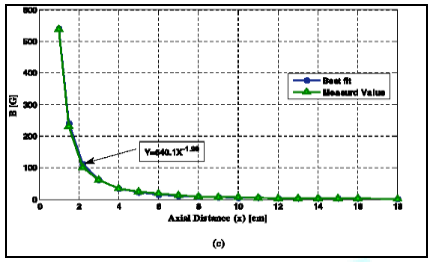
$$Vh = K4\ H - Q\ K2\ 2 \quad \ldots\ldots.(6)$$

where $K4 = K1K3$ = constant.

Thus, the output (Vh) of Hall sensor is nonlinearly related with volume flow rate (Q). Since at low flow rate, the float height (h) is small so we may assume that H h. Hence, the equation (6) may be approximated as

$$Vh = K4\ H2\ \ 1 + 2Q\ K2H \ldots\ldots\ (7)$$

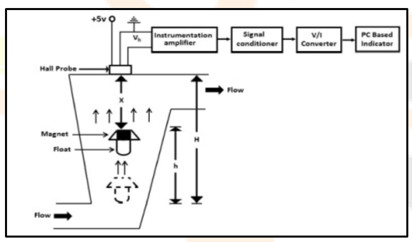
Thus at low flow,



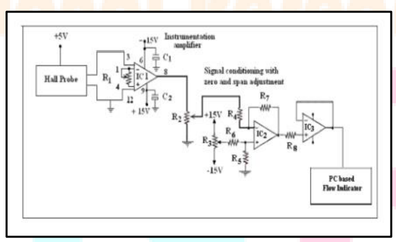
(c) Hall sensor output is linearly related with flow rate.

DESIGN

A circular permanent magnet with an inner radius of 11 mm, a depth of 8 mm, and a breadth of 11 mm is used in this design, with a value of H of 250 mm. A Solid-state Hall-effect sensor (SS490) with a dimension of 0.160 x 0.118 inch and a power consumption of 7mA at 5V DC was employed in this study. It has a positive temperature coefficient of (+0.02 percent /°C) with a precision of 3% and a temperature range of 40°C to +150°C. Stainless steel is used



(d)Diagram of the proposed transducer along with float and Hall probe



(e)Circuit diagram of Hall sensor-based flow transducer.

The signal conditioner circuit using INA101 has very low noise instrumentation amplifier is shown . Let the signal conditioner circuit be calibrated for flow rate in the range from Q1 L/min (liter per minute) to Q2 L/min for which the sensor output varies from Vh1 mV to Vh2 mV or the float. We can deduce from equation *(6)*

$$.Q = K2H - K\ V\ 1\ 2\ h \ldots.\ (8)$$

$$where\ K = K2\ (K4)\ 1\ 2 \ldots..\ (9)$$

Assuming, $y = 1\ V\ 1\ 2\ h$, the equation *(8)* is reduced to

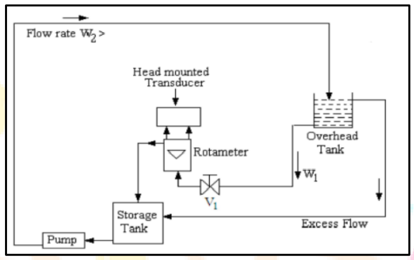
$$Q = K2H - K\ y \ldots\ldots.(10)$$

$$y = -a\ Q + b \ldots..\ (11)$$

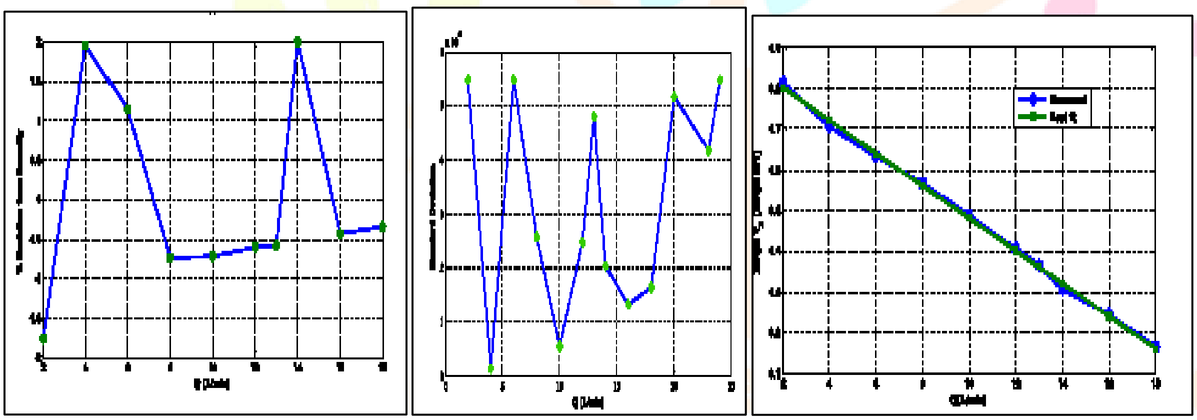
where $a = 1\,K$ & $b = K2H\,K$…… (12)

EXPERIMENT

With the experimental set up as indicated, the experiment is carried out in two steps. At room temperature, tap water is employed as a process fluid. The system includes of a 300-litre underground tank and a 300-litre above tank. The tanks are connected by a 25 mm ball valve, rotameter (2-24 L/min), and pump (1, 230 V, 370 watt) to a 25 mm diameter pipeline. The proposed Hall sensor based rotameter transducer unit's characteristics are determined in the first step, and the transducer is connected to the PC via signal conditioner, opto isolator, and DAS card in the second step, and the corresponding static characteristic of the entire flow indicating system is determined. The graph below shows the characteristic graph derived by graphing Hall sensor output versus flow rate. The standard deviation curve for six data was plotted after the experiment was repeated six times in both rising and decreasing modes. Table I shows the experimental results. These are the linearization features derived by graphing the inverse square root of Hall sensor output voltage against flow rates. The difference in percentages from linearity of characteristics.



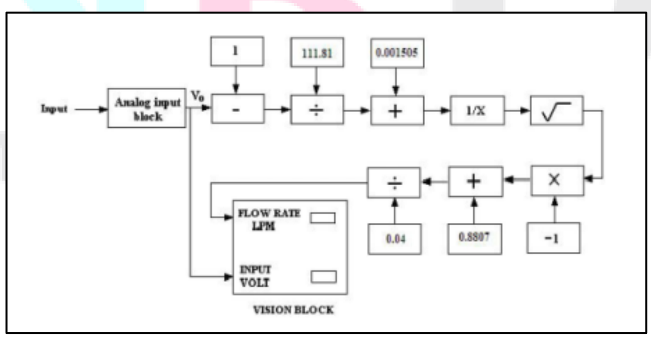
(f)Experimental setup



(g) Hall sensor output against flow rate.(h)Standard deviation curve of the Hall probe-based flow transducer.

TABLE I
EXPERIMENTAL DATA FOR STATIC CHARACTERISTIC OF FLOW TRANSDUCER

Sl No.	Flow rate (L/min)	Hall Probe voltage (mV)					
		Set 1		Set 2		Set 3	
		Increasing	Decreasing	Increasing	Decreasing	Increasing	Decreasing
1	2	1.51	1.5	1.5	1.51	1.51	1.5
2	4	1.84	1.84	2.01	1.84	1.84	2.01
3	6	2.31	2.31	2.3	1.3	2.31	2.3
4	8	3.11	3.11	3.11	3.11	3.11	3.11
5	10	4.23	4.23	4.23	4.22	4.21	4.22
6	12	6.87	6.87	6.87	6.87	6.87	6.07
7	13	7.47	7.48	7.48	7.48	7.48	7.48
8	14	10.73	10.73	10.75	10.73	10.73	10.75
9	16	16.73	16.73	16.75	16.73	16.73	16.73
10	18	27.29	27.29	27.28	27.29	27.29	27.28
11	20	61.81	61	61	61.81	61	61
12	22	144.9	144.9	144.9	144.9	144.9	144.9
13	24	280	280	280.1	280.1	280	280



(i)Block diagram of PC-based signal-processing unit.

CONCLUSION

The measurement system has a fairly simple design. Because the Hall sensor and permanent magnet are now widely available at low prices, the flow transducer will be inexpensive. Because the Hall sensor is not in touch with the liquid and the permanent magnet has a long-life stability, the transducer's lifetime will be extended. Using the same software, the measuring system can be integrated into a control loop with a virtual controller. As a result, within a specified limiting range of flow rate for which equation (1) is true, the suggested PC-based flow indicator may be anticipated to have good acceptability in industry in present PC-based Instrumentation systems. The measuring instrument's range can be extended by changing the rotameter's design.

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