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ELECTROMAGNETIC CONSUMER SENSOR

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Abstract

The sensor analyzed in this article is based on the law of electromagnetic. Also, compared to existing methods, it measures the amount of flow in the pump pipes more accurately and significantly improves the time of service.

Keywords: *electromagnetic induction, electrode, electric driving force big pipe, MatLab, modele, two phases, bubble.*

Introduction. An electromagnetic flow meter is based on Faraday's law of electromagnetic induction and measures the flow rate by measuring the induction voltage when a liquid flows through a magnetic field. An electromagnetic flow meter is used as one of the most widely used water flow meters in large pipelines.

The electromagnetic flow meter has high accuracy and does not cause pressure loss in a large pipe. Due to its high accuracy and absence of moving parts, the electromagnetic induction flow meter has wide advantages in measuring water consumption in irrigation systems, as well as in large pipelines of food, pharmaceutical and other technological industries.

In recent years, electromagnetic flowmeters have been widely used to measure oil-water two-phase flow [1].

Electromagnetic flow meter has unique advantages when used in multi-phase flow, such as there is no significance of velocity distribution and there are no parts to obstruct the flow in the pipeline, but the basic theory of this measuring sensor is based on single-phase flow.

When used to measure oil-water two-phase flow, its electromotive force distribution changes with the formation of an oil bubble, resulting in measurement deviation (Fig. 1). As a result, the response character of the electromagnetic flow meter to oil bubbles is analyzed [1].

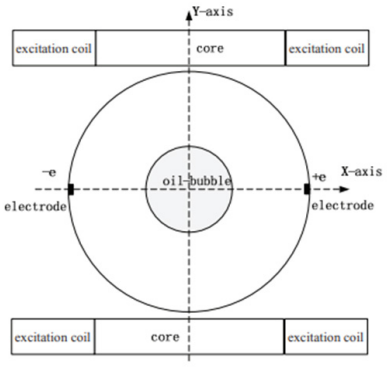


Fig. 1 Simulation model that oil bubble exists in the center of pipeline[1].

The basic theory of electromagnetic flowmeters is that charged particles in a conductive material moving in a magnetic field experience a Lorentz force that moves in a direction perpendicular to both the movement of the material and the applied magnetic field. Williams[2] applied a uniform transverse magnetic field perpendicular to the line connecting the electrodes and to the motion of the fluid. His experiments showed that for the same velocity profile, the flow rate is directly proportional to the voltage measured between the two electrodes.

Materials and analysis. The principle of operation of electromagnetic flowmeters is based on the measurement of the electromotive force generated in the current-carrying liquid flow under the influence of an external magnetic field.

The scheme of the electromagnetic consumption sensor is shown in Fig. 2.

Between the N and S poles of the magnet, the liquid pipe 1 passes perpendicular to the direction of the magnetic field lines of force. The part of the pipe passing through the magnetic field is made of non-magnetic material (fluoroplast, ebonite, etc.). Diametrically opposite measuring electrodes 2 are installed on the pipe walls. Under the influence of the magnetic field, the ions in the liquid move and give their charges to the measuring electrodes, creating an electric current in them. In proportion to the rate of water consumption, the value of the electric driving force is determined by the basic equation of electromagnetic induction when the magnetic field remains unchanged[1].

$$E=B*D*v_o'rt \qquad (1)$$

Here, B is the resulting electric magnetic induction between the magnetic poles, Tl; Inner diameter of D-pipe (distance between electrodes), m; vo'rt- average speed of flow, m/s.

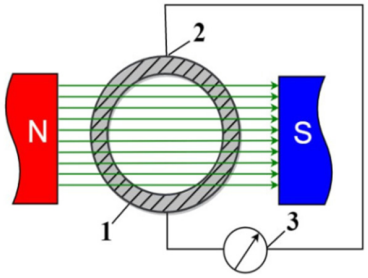


Figure 2. Inductive consumption sensor.

If we express the speed in expression (1) by volume consumption Q, the following expression (2) is formed:

$$E=4B/\pi D\ Q \qquad (2)$$

From this expression, it follows that the value of the electric driving force in a constant magnetic field is proportional to the consumption. Induction flow meters can provide flow measurements in pipes with a diameter of 3...1000 mm and larger, at a limit of 1...2500 m3/h and more, when the linear velocity of the liquid is up to 0.6...10 m/h. Accuracy class of water consumption measuring sensors is 0.6; 1; 1.5; 2; 2.5.

Fig. 3 shows the potential distribution arising from an imposed, linear single phase (water) velocity distribution in the flow cross section.

For a more accurate value of a given consumption, it is taken into account that the velocity distribution varies along the cross-sectional surface of a large pipe. Therefore, the surface is divided into 7 parts and sixteen electrodes

are placed at an angle of 22.5.

Electrodes are designated by e1, e2, etc. The electrodes are connected in pairs with the ones on the opposite side with the electronic circuit shown in Figure 4 below [3].

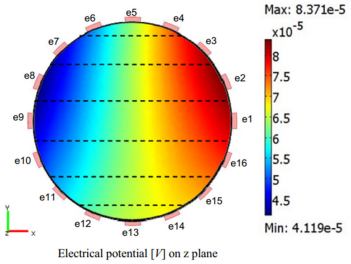


Fig. 3. Simulated induced potential distribution for the axial flow velocityvarying linearly from 0 ms-1 at y=-0.04 m to 2 ms-1 at y=+0.04 m[3]

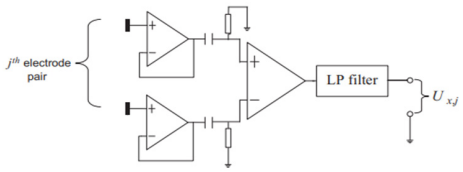


Fig. 4. Electronic circuitry for measuring the flow induced potential difference between each electrode pair[3].

Conventional electromagnetics use metal electrodes inserted into the wall of the measured pipe to obtain a current signal.

Discussion. Today, relevant researches are mainly focused on speed distribution generalization and electromagnetic consumption measurement[4][5]. In order to accurately determine the velocity distribution of the liquid along the cross-section of the large pipe, several electrodes and stirring rods are installed on the outer wall of the measuring pipe. Appropriate technology can be used in applications such as open channels, multiphase flow, and weakly conductive fluid measurement[6].

The resulting expression (2) was modeled in the MatLab program. As a result, our model in Figure 5 was created.

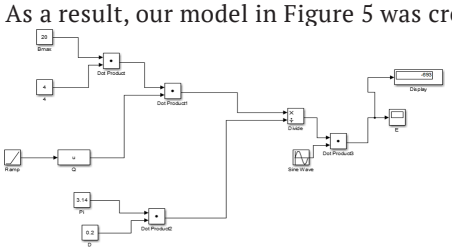


Figure 5. Model of electromagnetic flow sensor in MatLab program.

In general, the magnetic field and current profile in the measuring pipe are not the same. Thus, during the design, the structure and size of the sensor should be carefully considered, and the methods of making the distribution of the magnetic field as uniform as possible should be used to make the relationship between the induced voltage U and the current velocity v as simple as possible.

At least two detection electrodes are installed on the pipe wall perpendicular to the direction of the magnetic field and flow velocity to receive the induction signal. The junction capacitance is formed by the measured liquid, the measuring pipe wall and the detecting electrode.

When the corresponding values of the model built in MatLab program are given, the resulting signal (Fig. 6) is generated. As a result of the signal, the increase in consumption corresponds to the higher values of the generated electric driving force.

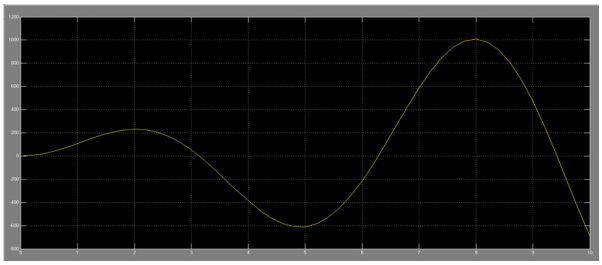


Figure 6. Graph of water consumption (Q) versus electric power (E).

According to the expression (2), the dependence of the amount of consumption on the value of the electric power is proportional.

Conclusion. The method of direct contact of the electrodes with the liquid leads to an electrode circuit.

Complex electrochemical, electrokinetic and other types of processes take place in the contact zone between the electrodes and the moving liquid.

These factors cause the measuring instrument to generate signals that interfere with the useful signal and cause difficulties in operational processes.

The development of a measurement method that is easy to operate in large pipelines, energy-efficient, and does not have direct contact with the liquid to be measured remains a current requirement.

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