Study on Design of Electromagnetic Flow meter

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Abstract

Electromagnetic flow meter by measuring the varying of magnetic flux, which is related to the velocity of conductive flow, can measure the rate of fluids very carefully and precisely. Electromagnetic flow meter operation is based on famous Faraday's second Law. In these equipments, the constant magneto-static field is produced by electromagnet(winding around the tube) outside of pipe and inducting voltage that is due to conductive liquid flow is measured by electrodes located on two end side of the pipe wall. The fundamental concept to design the electromagnetic flow meter; exciting winding and simulations will be shown by figures, simulation graph representation for better understanding and improvement.

Keywords: Electromagnetic Flow Meter, Induction Voltage, Finite Difference.

Introduction

ELECTROMAGNETIC flow meters rely on the Faraday principle, that works with Emf which generated by changing on magnetic flux density. The magnetic field produces by exciting wire in two kinds of DC and AC excitation systems. Therefore, induced voltage between electrodes calculated by simple equation

\[ E = B \cdot d \cdot m \cdot \nu \]

that illustrate the operation of an electromagnetic flow meter that based on the Faraday's law. In above equation, \( B \) is magnetic flux density, \( d \) is length of conductive which is equal to diameter of the pipe and \( m \) is mean flow velocity.\[1\]-[3], [6], [5]

By selecting constant magnetic field, the magnetic potential is directly proportional to transposed velocity of flow[1]-[5], [10]. For measuring of difficult fluid velocity such as slurry, melting material and special liquid by electrical conductivity is useful. In [1], [5], [6] a primary design is presented by the form of a two-dimensional weight function, that shows profile the velocity-to-voltage signal ratio of flow in cross-section pipe.

The operation of electromagnetic flow meter by circular cross-section is presented in [3], [8]-[9], in comparison with rectangular cross-section or open channel on which the induced voltage is independent from the distribution of fluid velocity [6]-[7], [11].

In this paper we are going to study about design and modelling of electromagnetic flow meter with homogeneous magnetic field and effective velocity of fluids on induced voltage. Also representation of operation of EM flow meter, effects of fluid conductivity coefficient and effective of the fluid level in pipe on induced voltage.

2. GENERAL OPERATION PRINCIPLE OF EM FLOW METER

The operation of electromagnetic flow meter based on Faraday's law that is known from theoretical analysis which is seen for static magnetic field. The produced voltage signal is consistent of the volume rate of fluid flow in transposed velocity profile. The dependence of induced electrical voltage, in measurement region to fluid velocity \( \nu \) and magnetic density of flux \( B \) is shown in Fig. 1.

![Fig.1 Basic model of EM](image1)

EM flow meter that is consist of pipe with circular cross-section for passing a fluid, producer of magnetic field in the direction of fluid and a couple of electrodes on the cross side of pipe wall. [5] Fig.2

![Fig.2 Schematic view of EM](image2)
non-magnetic ones because of the self-influence. Magnetic field interaction that is caused to generate an electrical field \( E \), inside fluid by positive (negative) ions movements of fluid that is based on Lorentz law. Therefore, this electrical field can present by gradient of electrical potential.

3. METHOD

In this paper we are going to study Electromagnetic flowmeter by simulation graphs and figures.

**Structure of E.M. flow meter**

Entirely, electromagnetic flow meters are made up two sections, signal detecting unit and signal processing unit. Signal detecting is included of non-conductive tube for fluid flow, electrodes and electromagnet parts. The electrodes are considered as copular shape like. The magnetic field is usually produced by a pair of identical circular coils that spaced one radius apart and a laminated yoke. Also, they wound the current flows through both coils in the same direction.

The electromagnet can supply with two kinds of excitation, AC and DC. After all, most of measurement are done on low-conductive fluids, we can use of sinusoidal exciting system by AC power supply. This kind of power supply can be controlled by frequency convertor of the power supply that can decrease the peaks of the noise caused by AC voltage which is arisen into error signals in the detecting section of this kind of flow meter by AC excitation.

The second part of the electromagnetic flow meter, we have signal processing that shown on Fig. 4. In this section, detecting signals in comparison with small unwanted voltages are filtering then amplifying [4]-[6]

![Image](Fig.3)

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![Image](Fig.4)

**Fig.4**

4. SIMULATED ANALYTICAL GRAPHS

The distribution of produced magnetic field and so distribution of electric field between two electrodes has been shown in Fig. 5 and 6, respectively. Also, in the Fig. you can obviously seen the effects of produced magnetic field lines on electrodes by high conductivity coefficient, as a result the nearly homogenous magnetic field inside the tube can clearly seen. [5]

![Image](Fig.5)

**Fig. 5 Distribution of magnetic field inside tube**

![Image](Fig.6)

**Fig. 6 Electrical distribution around electrodes**

The results for voltage variations between two electrodes for difference state of fluid level are shown in Fig. 7 and Fig. 8.

The distribution of electric potential between electrodes in cross-section measurement region can be seen in two dimensional and three-dimensional states that are illustrated fully filled pipe and 60% filled pipe condition. [5]

![Image](Fig.7)

**Y-axis**

**Fig. 7**
The distribution of electrostatic potential for fully filled pipe condition is symmetrical. In contrast, the state of inhomogeneous on fluid flow for 60% filled pipe condition is shown obviously where it is because of the fluid-to-air conductivity coefficient ratio effect. [6]

The induced voltage between two electrodes by changing conductivity coefficient of fluid flow for two different velocities of fluid inside the tube is shown in Fig. 10 and Fig.11. [5]

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5. SUMMARY AND CONCLUSION

We present the analysis and design of circular E.M. flowmeter. This analysis is based on induced voltage as rely on the Faraday's law. According to simulation results, we can calculate the distribution of magnetic flux density on the flow cross-section of tube that is almost uniform. Comparatively, in our design, the outcomes of induced voltage variation between electrodes in fully filled tube state by 60% filled pipe condition were studied.

We describe the effect of increasing fluid flow velocity and fluid conductivity coefficient on electromagnetic flow meter, perfectly. This method of measurement for fluid flow have very wide application arena, which can entirely use for any type of fluid like acids, polymer in chemical industry, and especially for their infusion.

REFERENCES