KUMARASWAMY K L
and
T. KRISHNA RAO

Sensitivity variation of a flowmeter with varying shapes of the target

Accurate measurement of flow rate of fluids is known to be an essential requirement with various industrial applications. Flowmeters have been realized with different sensing methodologies; among them the target flowmeter/ drag flowmeter has been in the mainstay for decades. In the present research work, the variation in the sensitivity of a target flow meter with varying shapes of the targets is evaluated by experimental results and simulation. Flow rates of water between 0 lt/s to 1 lt/s is considered for sensitivity evaluation of the target flow meter with target being flat faced, V faced and curved faced. The excellent agreement between the experimental results and simulation illustrates the efficacy of the analytics carried out in the present study.

Keywords: Flow rate, tensor flow, coefficient of discharge, target flow.

1.0 Introduction

Flow sensors are the devices which are used to monitor the variations in the flow-rate of a fluids i.e., liquids or gases. Flow meters/sensors are typically devices that can be used to measure the rate of gas, or liquid movement through it. Flow meters are also commonly known as flow sensors, flow gauges, liquid meters, or flow indicators. A better quality of the industrial process essentially demands for an accurate measurement of the flow rate of liquid and gases [1]. Accurate flow rate measurement of gases is essential for the industrial process and it also does the control of flow rate [2]. Conventionally, flow meters measure the flow by employing two different methodologies, some flow meters monitors the flow as the amount of the liquid which passes through the flowmeter during a certain period of time. While other flow meters measure the flow by acquiring the total amount of fluid that has passed through the flow meter. In any case, the flow sensors are expected to record even the slightest variation in the flow rate and hence needs to be highly precise and accurate. Flowmeters can be of varying types which includes mechanical flow meter, optical flow meters as well as open channel flowmeters which has varying principle of operation. Amongst these broad classification, different kinds of flowmeters can be commercially found including positive-displacement meters [3], turbine flow meter [4], piston displacement-type flowmeter [5], laser doppler flowmeter [6], ultrasonic flow sensor [7, 8, 9]. The more common types of flowmeter includes coriolis flowmeters which work on the principle wherein the fluid flowing through the vibrating tube causes a change in frequency or phase shift or amplitude, which gives a measure of its flow rate [10, 11, 12]. A relatively recent development in industrial flow measurement came with the introduction of optical flow meter which effectively uses light to measure the velocity of a fluid flowing through a pipe [6].

Although there are many flowmeters available in the commercial market, there are very few versatile flowmeters with capability of tuning the sensitivity and range which can be utilized for variety of applications. Therefore, present article reports a study carried out on observing the sensitivities obtained by using target plates of varying shapes on the same target flow meter (TFM) and comparing the obtained results from three differently shaped target plates in order to optimize the output.

2.0 Experimental methodology

The sensitivity of the TFM device can be varied by attaching the target plates of different shapes as target in the TFM. The present paper explores the possibility of tuning the sensitivity of a TFM by varying the shapes of its target plate. To study this, three individual target plates of different shapes is fabricated. The three different shapes of the target plate studied in the present work are:

1. Flat target plate
2. Curved target plate
3. 'V' shaped target plate

Each target plate is attached individually to the TFM and the experiment is carried out to test its response. The experimental set up is shown in Fig.1. The TFM is installed in a laboratory set up for experimentation which includes a pipeline attached along with the commercial flowmeter inline, to a closed loop water circulatory system with the pipe

Messrs. Kumaraswamy K L and T. Krishna Rao, Department of Mechanical Engineering, Global Academy of Technology, Bengaluru, Karnataka, India. E-mail: krishnaraot@rediffmail.com



Fig.1: Experimental set up

diameter of 50.8mm, as can be seen in the Fig.1. Flow rates of water between 0 lt/s to 1 lt/s is considered for sensitivity evaluation of the target flow meter. The laboratory set up is formulated in such a way that the flow of the water can be controlled externally using valves. The output of the TFM with varying target plates are recorded and compared. Varying flowrates of water are provided to circulate in the system and the response of TFM is acquired. Later, the responses obtained by different shapes of target plates are compared to each other. The results are discussed in the upcoming sections.

3.0 Results and discussion

It is well known that the force experienced on the target plate is given by (1) when the fluid is flowing in the pipe.

$$F_D = \frac{1}{2}\rho V^2 C_D A \quad \text{... (1)}$$

Where, F_D represents the drag force, r is the density of the fluid, V denotes the flow velocity relative to the object, A is the reference area, and C_D is the drag coefficient which is a dimensionless coefficient related to the object's geometry. The response obtained by the TFM, when the target plates of varying shapes are attached to the cam of the TFM is as shown in Fig.2. It is clearly observed from the experimental results that the curved plate reflects the highest sensitivity as compared to the flat plate and the V shaped plate. The order of sensitivity in increasing order being flat plate, V shaped plate and curved plate respectively. Apparently, the curved plate offers more contact to the flowing fluid leading to higher TFM output which indicates more sensitivity offered by the curved plate as compared to the flat plate or V shaped plate. Different shapes of the target plate offers varying contact area of the target plate with the flowing fluid. More contact area of the target plate effectively increases the area of the target plate which directly comes in contact of the fluid flowing inside the pipe. This increase in the contact area results in more drag force experienced by the target plate, as the drag force experienced by the target plate is directly proportional to the area of contact of the fluid as mentioned in equation 1. The increased drag force experienced by the target plate eventually results in increased change in the TFM output. Therefore, it can be observed from the results obtained with varying shapes that the TFM output (sensitivity) increases with the increasing area of the target plate. Therefore, the maximum sensitivity is achieved by curved shaped target plate followed by the V shaped target plate and the least sensitivity being achieved by the flat shaped target plate.

The mathematical simulation of the TFM output for the three different shapes of the target plate is also carried out

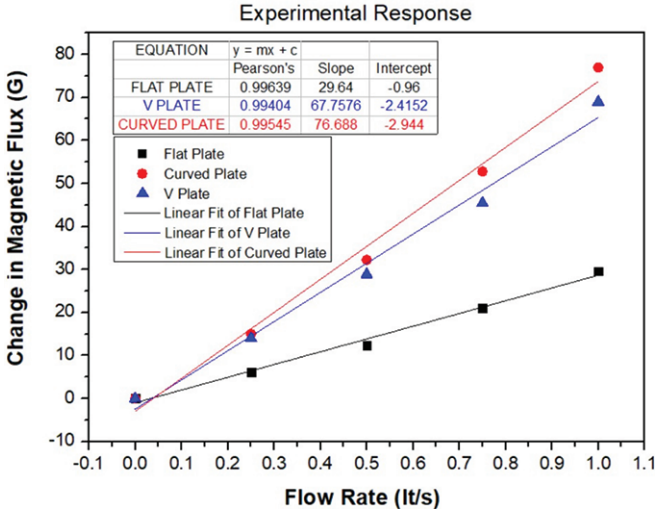


Fig.3: Mathematical simulation results of TFM output with varying shapes of the target plate

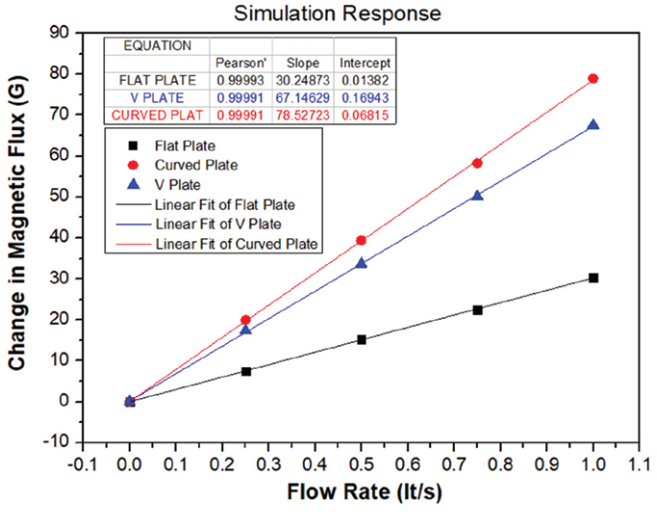


Fig.2: The response of TFM with varying shapes of the target plate

and compared to each other. The obtained results of the mathematical simulation is as shown in the Fig.3. The simulation results are in good agreement with the experimental findings which proves the efficacy of the experiments conducted.

4.0 Conclusion

Three different target plates of varying shapes are fabricated to explore the sensitivity variation of the developed TFM. The experiments are conducted individually with each target plate and their responses are analysed and compared for optimization. It is observed that the curved target plate offers the maximum sensitivity followed by V shaped target plate and the flat shaped target plate. The experimental findings are also found to be in good agreement with the simulation results which proves the efficacy of the present study. The results show that the sensitivity of the TFM can be tuned effectively as per the requirement of the application by utilizing the target plate of varying width or varying shapes.

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