Corrosion Detection of an Orifice Plate for Flow Rate Measurement using Heat Transfer Mechanism

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Abstract. Flow rate measurement is a critical parameter in industries which is measured by various techniques. But among them the most commonly used method of flow rate measurement is using differential pressure. A restriction placed in the path of flow produces a drop in pressure which is measured. The fundamental principle of bernoullis is used to compute the volumetric flow rate. The orifice plate is the primary sensing element widely used in differential pressure based flow measurement. Hence the accuracy of the flow rate depends upon the dimensions of the orifice plate. The reason for this is the flow rate is computed assuming that the dimensions of the primary sensing element is constant. Due to this reason it is important to detect any damages to the orifice plate. Erosion and plugging of contaminants are common problems encountered in this method. Improper values of pressure adversely lead to drop in transmitter accuracy. This paper provides a novel method for detecting damages in an orifice plate without visual confirmation. This technique provides a significant advantage of providing diagnosis information related to an orifice plate which thereby helps to measure the flow rate of fluids using differential pressure method with accuracy. This objective of our work is focused towards process industries where majority of the flow rate is measured using differential pressure method.

Keywords: Corrosion, orifice, heat, transfer, visual, diagnosis.

INTRODUCTION

In the conventional method of differential pressure type flow meters, there is a high possibility for particles carried over in the flow to cause corrosion in the primary sensing assembly such as an orifice plate such that it becomes impossible to perform a fluid control as is intended to obtain a targeted flow rate value. To eliminate this problem a diagnostic mechanism is required to identify problems in the primary sensing element without the need of visual inspection. The proposed method relates to fluid process monitoring systems using heat transfer mechanism.

1. EXISTING METHODOLOGY

Inspecting the primary sensing element by manually opening and verifying damage is the common method used to detect plugging or corrosion. [1]. The recently proposed method for detecting corrosion was to send a check pulse periodically along with the measurement signal from a pressure transmitter [2]. The check pulse enables a disturbance in the process loop and checks for the transmitter to detect it. If the transmitter does not identify the disturbance an alarm signal is generated indicating either corrosion or plugging. Another method for detecting corrosion is to measure static as well as differential pressures. The correlation between oscillations due to static pressure and differential pressure are analyzed. If the measurement does not correlate, then an alarm signal is
generated. Another method for detecting disturbances in the sensing element is by measuring static pressure and filtering them. If the variance of the noise signals is less than a threshold value then it indicates a plugging in line [3]. Conventional method of corrosion detection involves a non invasive method of detecting metal corrosion using Passive Inter modulation generated by multi tone radio signals flowing through galvanic corrosion junctions [4]. This invention involves two probes, a transformer and a spectrum analyzer to perform complex processing to detect the corrosion. Thus if the proposed method is applied for detecting corrosion in orifice plate the cost and complexity would simply exceed that of the transmitter assembly used.

The method of Non Destructive Evaluation (NDE) using guided ultrasonic wave provides a means of cost effective methodology for identifying hidden corrosion in areas with difficult access [5]. This method has been proven effective in applications where the structures have less thickness. The feasibility of applying this technique for materials with high thickness has not been that effective. A shear guided horizontal wave used has a unique feature of in-plane polarization which offers a more economical approach [6]. They can also be used to identify corrosion in high density metals. In another research a novel of using pulsed ultrasonic echo technique was proposed which obtained a satisfactory result.

Another method of NDE is by using eddy currents for identifying hidden corrosion of metals. This technique uses alternating current generated using a coil and detecting the response of the material to the generated eddy current. Any deviations in the impedance or phase shift in the receiver circuit shows corrosion [7]. Early methods of eddy current technique had the disadvantage of detecting corrosion only at limited depths. But with the recent advancements in signal conditioning circuits this problem has been overcome. Thermography technique is an alternate method used to detect surface corrosion. It provides a quick and accurate method for detecting corrosion [8]. It detects the differences in wavelength emitted from a ideal surface and a surface with crack. Thermal wave systems generates a pulse of thermal energy from the surface and checks for impedance changes [9]. The most widely used technique is by using an IR camera to obtain the thermal images and process it using image processing algorithms. Accelerated flows with hazardous chemicals are the major factors leading to corrosion in the primary sensing element. Measurement of pressure drops at various locations can also lead to identifying corrossions [10], [11].

2. PROPOSED METHODOLOGY

The existing methodologies are suitable for detecting corrosions in pipelines as well as industrial vessels. However the geometrical construction of the primary sensing elements used in flow rate measurement makes it difficult to implement the above techniques. To overcome the said problem we have proposed a diagnostic system using heat transfer technique in metals. The orifice plate is heated by passing current through it where a temperature sensor measures the temperature of the orifice plate and conveys the value to an electronic controller through a cable concealed in the transmitter. The transmitter processes the temperature sensor output and generates a current required to reach the destined temperature. The orifice plate described here corresponds to the application of flow rate measurement by creating a pressure drop across it. The pressure upstream and downstream is measured and based on the difference in pressure the volumetric flow rate is derived. This method of flow rate measurement is based on the Bernoulli’s principle which states that the total energy in a closed pipe is always constant. In the case of flow rate measurement the restriction creates an increase in kinetic energy downstream which creates a decrease in potential energy. The downstream pressure
Tapping is taken at the vena contracta point where the pressure is minimum and velocity is maximum. The diagnosing system comprises the orifice plate which is installed between two mating flanges of a pipe with appropriate gasket between them. The diagnosing method is performed by the computing device which includes a CPU, memory, A/D converter and has functions of providing a constant power supply, measuring analog inputs, getting user defined inputs and processing the inputs and providing a output indicating corrosion. The temperature sensing element is configured such as to output the temperature of the orifice plate which is related to the amount of current passed through it. When a current is passed through the orifice plate, heat energy generates in the conductor. The heating effects of electric current depend on three factors:

- The resistance of the conductor. A higher resistance produces more heat.
- The time for which the current flows. The longer the time the amount of heat production is high.
- Higher the current the amount of heat generation is also large.

The current required to heat the orifice plate within a prescribed time is predetermined and remains constant under normal conditions. A controller with a processor is provided to supply a constant current to heat the orifice plate. It has the provision of user to input a prescribed time limit and destined temperature. The time taken to heat the orifice plate and attain the desired temperature is entered in the processor. This value is pre calibrated and depends upon the material, surface area and thickness of the primary sensing element. The processor supplies the constant current and measures the time taken to reach the desired temperature. If the desired temperature is reached at the prescribed time limit then there is no damage to the orifice plate. If the temperature is achieved in a shorter time period then the surface area of the orifice plate is corroded and the processor conveys this information to the user through a display. The process of diagnosis is done with the process fluid isolated as the flow rate can cause an additional effect in maintaining the temperature. Higher flow rates can cause the temperature of the orifice plate to reduce which will lead to an inaccurate result as to which we cannot differentiate the reason for the temperature difference.

![Figure 1. Construction of Orifice Plate fitted with Temperature Probe](image)

Figure 1. Construction of Orifice Plate fitted with Temperature Probe
3. RESULTS AND CONCLUSION

The experimental was conducted at a flow rate of 1200 m3/hr at a pressure of 1.5 kg/cm2 in a process pilot station. A 1 inch orifice plate was used for testing the method and a 12V, 10Amps battery was chosen to heat the element. The time span required to reach 70°C was 67 seconds. The orifice plate was replaced with a damaged where the temperature of 70°C was reached in 52 seconds. The accurate relationships between these parameters are being researched further. This technique accurately diagnoses the orifice plate within a short time span. This diagnosis method has the advantage that it does not require to visually inspect the plate by removing it from the process piping. Furthermore the system is planned to be enhanced to deliver the current to the orifice only during scheduled diagnosis or in regular time intervals.

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