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Technical Bulletin Series:
Magnetic Flow Meters

TBWFP – 007
ISSUE: V4
DATE: Dec 2023
ECRO: 1674
PAGES: 2

ELECTRODE COATING

INTRODUCTION

Since the commercial introduction of electromagnetic flow meters in the early 1950's, various techniques have been used to eliminate electrode coating. While these coatings only appear in a very small number of applications, they have previously caused errors in measurement.

The most common coating is an insulating type coating that adds impedance between the fluid and the electrodes. This impedance can cause a loss of signal to the electrodes that creates a decrease in flow reading.

It should also be noted that coatings that are the same conductivity as the process, will have no effect on the flow meter's accuracy.

METHODS OF OVERCOMING ELECTRODE COATINGS

Burn Off

In the early 1960's, line voltages (120 or 240VAC) were applied across each electrode while the meter was full of process fluid. This would cause current to flow through the electrode that would burn off any coating. This however would also cause pitting in some electrodes. Flow measurement was also lost during this burn off period, which would sometimes be several minutes long.

Mechanical Scrapers

This scraper generally consisted of an electrode with a shaft through its center, with a brush on the process side and a motor on the external side. The motors would be periodically turned on to brush or scrape the electrode clean. While these were effective, they were expensive and subject to mechanical failure due to sealing, motor burn out or jamming of the scraper assembly. In general they were found to create more problems than they solved.

Ultrasonic Cleaning

This method involves attaching crystals to the rear of the electrodes and then applying a high voltage high frequency signal to them generated from an ultrasonic generator. The high frequency oscillation of the crystal would remove relatively hard coatings. However for sticky and greasy type products, it is not very effective. Other problems include oscillations, loosening electrodes causing leaks, also cavitation at the electrode tips causing pitting of the electrodes.

Amplifier Impedance

The error caused by electrode coating is also related to the impedance at the amplifier input. As electronic technology has advanced, amplifier impedance's have become higher which has reduced the effect of electrode coating.

The % error caused by coating can be calculated using the following formula: **% error = *C/(A* + C) x 100**

Where C = Coating impedance in Ω
A = amplifier impedance in Ω

- Coating impedance's typically vary greatly, however a coating of 10^6 Ω would be considered high, i.e. 1 Meg Ω.
- Therefore an amplifier with an impedance of 10^7 could expect errors of up to 9.09%.
- Using an amplifier with an impedance of 10^8 could expect errors of up to 0.99%.

It can be seen that by increasing the input impedance of the amplifier, the expected error can be substantially decreased.

Protruding Electrodes

By having the electrodes protruding into the flow stream, the velocity of the process assists in keeping the electrodes clean. Electrodes in this case normally have a sharp point protruding into the process by approximately 5mm.

This method typically works well, however it is subject to the velocity reaching 1.5 m/sec. Its effectiveness is also subject to the abrasiveness of the process.

In very abrasive processes, electrodes can be subjected to wear on the sharp point and may eventually require replacement. However it is very unlikely coating will occur in an abrasive process.

Removable Electrodes

Removing the electrodes enables them to be cleaned and refitted. This process would take place at intervals determined by the nature of the process and coating.

The removal can typically be done without depressurising the line or stopping the process. There is however some concerns about doing this and it should normally only be done as a last option. The electrode is a critical part of the flow measurement and its position in the flow tube can affect the accuracy of the system. Disturbing the electrode cabling is also a concern, as the signal from the electrodes is in the range of micro volts. Therefore all connections and shielding must be maintained to a high standard as per the original manufacture. Any leakage or seepage around the seals into the outer housing will cause the system to fail.

Once electrodes have been removed and refitted, the integrity and accuracy is always in question. This method also is only possible up to relatively low pressures due to difficulty in overcoming pipeline pressure when returning electrodes to correct location.

SUMMARY

Burn-off, scrapers and ultrasonic cleaning were appropriate solutions considering the technology at the time of their application. Later developments have superseded them and provided better answers to the problem.

THE EMFLUX ANSWER

Combined Instrument Systems have taken the two most practical methods of electrode cleaning as detailed above, improved on them and added one new method. All three features are standard with Emflux flow tubes and the M500 Transmitter.

1. Protruding Electrodes

All of our flow tubes are fitted with domed protruding electrodes that enter the flow tube by approximately 3 to 5mm (depending on the flow tube size). Being domed they resist wear from abrasive processes while still gaining a cleaning effect.

2. Amplifier Impedance

With advancements in electronic technology, our latest model amplifier the M500 has an Input Impedance of 7 GΩ *($7x10^9$).* Using the formula detailed earlier, the % error equates to only 0.014% should a coating of 10^6 ohms occur. Even if the coating impedance was to increase by a factor of 10 to 10^7 ohms, the error would still only be 0.14%.

3. Electrolysis Method

The M500 transmitter has built-in continuous electrode cleaning. An internal circuit generates a square wave with a frequency of around 2 kHz and amplitude of 10V peak to peak. This signal is capacitively coupled to the detector head signal leads, and hence to each electrode. The degree of current flow is determined by series current limiting resistors in the M500. As the process must be electrically conductive and must also be earthed at each end of the meter, it follows that the 2 kHz signal causes current to flow from the electrodes to earth, the amount being determined by the current limit.

In practice, this small current flow normally restricted to a few mA, causes a degree of electrolysis to take place on each electrode. Any fat or grease deposits which attempt to build up on the electrode face, are thus lifted clear by the minute gas bubbles formed as electrolysis takes place and are swept clear of the meter bore. No appreciable erosion of the electrodes takes place, as any disposition that may occur from the material using DC polarisation is avoided by the use of AC at a relatively high frequency. Material is hence both lost and gained.

This method of cleaning has been successfully used in Emflux flow meters since the mid 80's, firstly in the A200 and due to its success it has now been incorporated in the M500. The use of these three methods ensures the accuracy of the flow meter is not affected by electrode coating. As they are standard features on Emflux flow meters, they are available at no additional charge.