International Journal of Engineering Research and Reviews ISSN 2348-697X (Online)
Vol. 5, Issue 3, pp: (1-5), Month: July - September 2017, Available at: www.researchpublish.com

Advancement in Surface Temperature Sensing Technology

[1]Nisha K.A., [2]Sanjana Shaleen, [3]Souvik Das

Control Systems Engineer, Fluor Daniel India Pvt. Ltd. Gurgaon, India

Abstract: **Temperature is one of the most critical parameters that govern smooth functioning of any process plant. Variety of temperature sensors are available for monitoring of temperature but for its selection, many factors should be taken into consideration like required range, accuracy, linearity, response time etc. The technique elaborated in this paper uses a surface temperature measurement assembly which measures process fluid temperature by reducing the complexities faced in conventional temperature measurement. A chemical manufacturer was encountering challenge of continuous and precise temperature monitoring along the transport line to keep the intermediate chemical in a desired state. By utilizing the non-intrusive pipe clamp design and temperature transmitter, accurate temperature control was achieved resulting in improved quality of intermediate chemical and hence final product. Another challenge faced by one of the oil producers was reduced productivity due to paraffin build up restricting the flowlines. Also, frequent visit to field for maintenance was required. The customer requirement was continuous monitoring of paraffin build-up with no pipe penetrations and welding connections to be part of this whole installation as it may fail under high vibration conditions. These issues were resolved by using a combination of non-intrusive pipe clamp sensor and temperature transmitter.**

Keywords: **Temperature, Intrusive, Non-Intrusive, Accuracy, Response Time, Leakage, Safety, Cost.**

I. INTRODUCTION

This paper throws light on the temperature measurement technique: internal fluid temperature measurement and surface temperature (pipe wall temperature) measurement. An intrusive temperature measurement technique measures the temperature of fluid flowing through the pipe. It is superior to surface measurement method in terms of accuracy and response time, but, they can lead to problems due to installation of thermowell like flow interference, introduction of a potential leakage point due to pipe penetration and also, thermowell is subject to corrosion, abrasion, vibration failure, cleaning and plugging. On the other hand, Surface temperature measurement is based on tracking of pipe wall temperature which heats up or cools down with respect to internal fluid temperature. But, the thermal response time and accuracy of surface temperature measurement techniques are adversely affected by wall thickness of pipe, ambient effects and process conditions (viz. process medium, flow rate, temperature). Traditional surface temperature sensors provides information of pipe wall temperature without facing any challenges related to design issues and complexity like wake frequency calculation required for thermowells by compromising on accuracy and precise temperature measurement of inline fluid. Recently a technology has been developed which is a blend of the merits that both the technique offers, which removes the complications of thermowell design while taking care of the accurate temperature measurement that a traditional surface sensor cannot.

II. PIPELINE TEMPERATURE MEASUREMENT TEHNIQUES

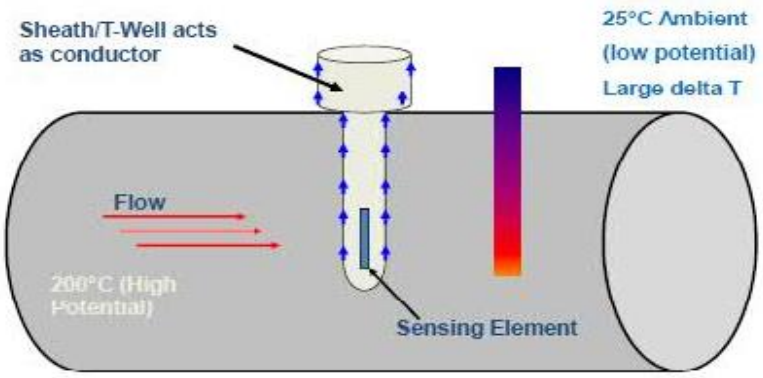
Temperature is one of the most critical parameters that govern smooth functioning of any process plant. Variety of temperature sensors are available for monitoring of temperature among which RTD and thermocouple are widely used in process industries, but for its selection, many factors should be taken into consideration like required range, accuracy, linearity, response time etc. In this paper, we are focusing on pipeline temperature measurement techniques which can be

broadly classified into three categories: intrusive type (with thermowell and without thermowell), non-intrusive type (surface sensor).

Intrusive Type Techniques:

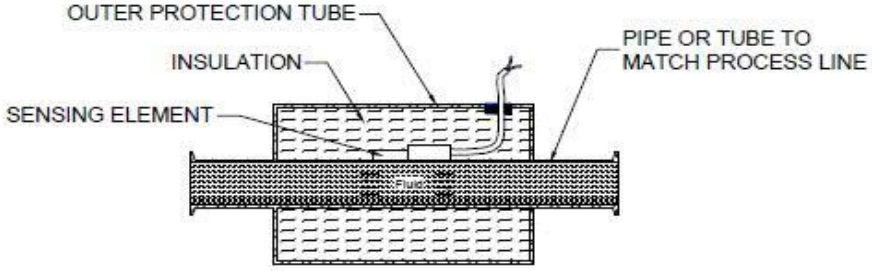
Traditional immersion type temperature measurement practice are most widely used in process industries which involves immersion of the sensor (RTD/ Thermocouple) inside the process flowlines with or without thermowell for process fluid temperature measurement. In direct immersion technique, sensor is directly inserted to the process line making direct contact with the fluid flowing through the pipeline which leads to fast response time and accuracy, but, on occasions when replacement or calibration of sensor is required the entire system needs to be shutdown. This drawback can be efficiently taken care by using indirect immersion temperature measurement in which sensor is inserted inside a metallic protection tube known as thermowell. Thermowell is the vital part of indirect immersion assembly as it is that mechanical component which protects the sensor from process which might be pressurized, hot and possibly corrosive.

For optimum temperature measurement, thermowell design is important criteria which involve selection of thermowell material, wake frequency calculation, construction type (tapered, straight or stepped). Most commonly used thermowell process connection types are flanged, threaded or socket weld. Process shutdown due to maintenance caused by bending, clogging or corrosion of thermowell is a time consuming activity which can be a nightmare for any industry. Conduction error due to heat loss along the wall from tip to flange of thermowell results in response delay. Main problem faced with intrusive type temperature measurement technique is requirement of pipe penetration to measure the fluid temperature which causes possible leakage point. Installation of traditional intrusive type temperature measurement assembly requires pipe penetration introducing leakage point in pipeline. Design consideration which must comply with the client and process specification like material, process connection, plant condition etc should be taken care for safe measurement.



Non-Intrusive Type Temperature Measurement Techniques:

Surface sensor measures the pipeline temperature which is a function of inline fluid temperature. Surface sensors reduces the risk of leak points, hence, are used where penetration in pipeline is not practical or acceptable to install for e.g. Custody transfer, regular pipeline cleaning is required (pig launcher/ receiver). These are installed in the pipeline with the help of screw, clamp or welding. In surface temperature measurement techniques, process temperature measured is a function of ambient temperature, surface temperature of pipe and thermal conductivity properties of assembly and process piping. Monitoring of ambient temperature is critical which can be achieved by proper insulation of the surface from environment effects like sunlight, rain, and wind as per the customer guidelines to achieve better accuracy.



a. Surface temperature measurement with weld pad

b. Pipe Camp assembly

Data Analysis:

1. Accuracy & Response Time:

These factors are dependent on the conditions to which the sensor is exposed and on the installation method.

- Intrusive Type

- Thermowell cannot be installed in pipes less than 2" in diameter.

- Non-Intrusive Type: Tests are being performed to get an accurate correlation between the process temperature and the surface temperature. Preliminary models are showing differences between 4% and 16%, depending on the process conditions.[1]

- Testing of response time of surface sensors cannot be done as per IEC 751, due to indirect exposure to process fluid. To achieve better response time silver or nickel measuring tips are used in non-intrusive type assembly.

2. Corrosion:

Corrosion can occur in both types of temperature measurement techniques:

- Intrusive Type

- Thermowell

a. Can be avoided by polishing the thermowell surface.

- Non-Intrusive Type

- Between clamp and the pipe:

a. Can be avoided by matching the clamp material with the pipe.

b. Using rubber seals/ gaskets inlay for clamp, avoiding galvanic corrosion between dissimilar materials.

3. Error in temperature measurement:

- Radiation error

- Convection error

- Stem conduction error: This is the most frequently occurring error in temperature measurement because of inadequate contact between measuring media and sensing element.

a. Intrusive Type: Insufficient immersion of sensor in process fluid results in measurement error due to ambient effect on sensor. A thermowell and RTD assembly requires at least 4.5" of immersion to minimize the error. A direct immersion RTD requires at least 10x the probe diameter plus the sensitive length. Most RTDs have a sensitive length of 1". So for a ¼" diameter RTD, the minimum immersion is 3.5". [2]

b. Non-Intrusive Type: Requires insulation against ambient condition as reading is highly influenced by difference in pipe wall and ambient temperature. Providing insulation over the sensor helps isolation of sensor from ambient conditions, thus, reducing chances of measurement error by up to 70%. Insulation is usually done by using a combination of thermally conductive paste epoxy, silicone rubber or similar material.

4. Application Area:

- Small diameter pipelines.

Measuring temperature in small diameter pipelines (0.25-4in) is challenging as it requires special considerations like sufficient space for mounting standard configuration that involves a sensor and a thermowell. Non-intrusive measurement on the other hand can measure temperature irrespective of line size. Pipe-clamp devices can be used on pipe sizes ranging from 0.5 to 48".[2]

- Process fluid (Toxic)

Fluids having toxic properties impose safety concerns not only for personnel but also for the whole sensor assembly. Non-intrusive measurement technique eliminates this complexity since it completely minimizes contact between the sensor assembly and the process fluid.

- Slurry

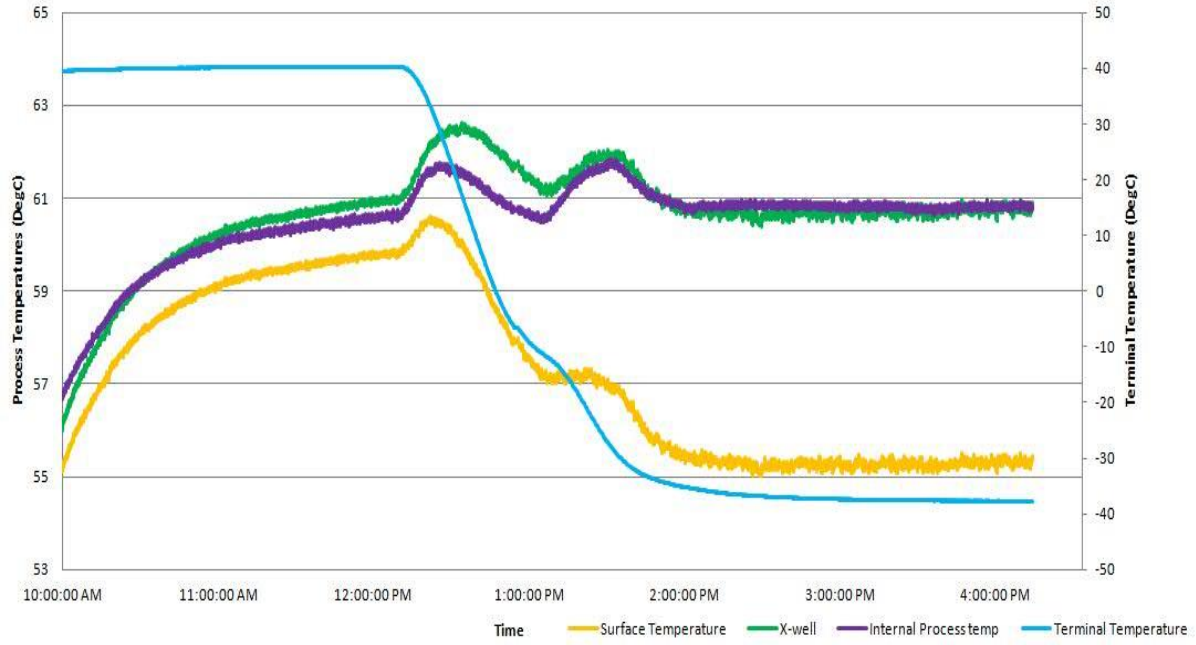
Heavy liquids and particulates may cause the thermowell to erode, weaken and gradually break it. Particularly in processes where periodic cleaning is required, it becomes cumbersome and time consuming to remove and replace the entire sensor assembly again. Non-intrusive measurement helps to combat this since its simple installation does not require any process shutdown for cleaning or calibration purpose.

- Leakage due to pipe penetration

Pipe penetration, welding connections etc. may create potential leakage points if high velocity fluids pass through the pipe. In such cases, vibration increases and that may lead to thermowell failure. Also, during revamp scenarios, many clients do not prefer cutting the pipe again for measuring temperature.

Advancement:

Accuracy and response time the major drawback of non-intrusive temperature measurement technology can be overcome to some extent by proper installation. To achieve higher accuracy, the ambient temperature and pipe surface temperature is measured and combined with thermal conductivity properties of the temperature assembly and process piping information like pipe material, schedule etc.[3]



The above graph represents the performance data of Non intrusive pipe clamp sensor along with Wireless temperature transmitter.

This performance data has been collected based on the following parameters:

- - Carbon steel pipe 4 inch schedule 40.
- - Process temp ~60 °C and Ambient 40 to -40 deg C.

Cost Analysis:

MEASUREMENT TYPE	COST PER UNIT(INR)
DIRECT IMMERSION (3 Wire RTD, Dual element)	18000/-
INDIRECT IMMERSION (3 Wire RTD, Dual element, Spring loaded, Extension type- Nipple-union, Immersion Length-14in with 300# thermowell)	101600/-
SURFACE (3 Wire RTD, Dual element, 18mtr cable, 4.5 mm Sheath dia, 316 SS weld pad with 5mm thickness, 28 mtr Sheath length)	25000/-
NON-INTRUSIVE (CLAMP ON TYPE) (3 Wire RTD, Single element, Silver tip, Extension type- Nipple-union, Extension length- 80mm)	50000/-

III. CONCLUSION

To conclude with, both the technologies have their certain application areas. In safety systems or where accuracy and response time cannot be compromised, intrusive measurements are the best choice. They provide the highest level of accuracy with issues related to design (wake frequency calculation), installation (penetration and minimum insertion length requirement) and maintenance (process shutdown). Whenever penetration of pipeline is not acceptable or where accuracy and response time requirements is not that critical and only temperature measurement is the prime motive, nonintrusive measurement should be considered because these techniques are having lower capital and operating expenditure, need less maintenance and do not require process shutdowns.

	DIRECT IMMERSION	**INDIRECT IMMERSION**	**SURFACE**	**NON-INTRUSIVE**
Operating Range	-200 TO 850 DegC	-200 TO 850 DegC	-200 TO 850 DegC	-200 TO 850 DegC
Accuracy	HIGHEST	HIGH	MEDIUM	MEDIUM
Thermal Response	FASTEST	FAST	SLOW	MEDIUM
Ease of installation	LOW	LOW	HIGH	HIGHEST
Cost	LOWEST	HIGH	LOW	MEDIUM
Safety	LOWEST	LOW	HIGH	HIGHEST

REFERENCES

[1] Rosemount Pipe Clamp Sensor - Emerson Process Management

[2] Intrusive-versus-nonintrusive-temperature-measurement (ProcessHeating.com)

[3] Accurately Measure Process Temperature without a Thermowell or Process Penetration using Rosemount Xwell Technology (Emersonprocessexperts.com)

[4] Images are taken from Wikipedia.