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A Comparative Study of Instrumentation Systems of a Gas Process Plant

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Abstract

The Challenges of 21st century are basically centralized to the proper utilization of energies, especially the natural resources. Natural gas (methane) is one of the most important sources of energy upon which other systems are dependent, e.g. power generation system as well as the economic or industrial development. The successful exploration of natural gas with other hydrocarbon components (petrol, diesel, octane etc.) depends on proper instrumentation and control. Inaccurate instrumentation may cause inefficient production or severe damage of the total system; consequently, economic losses. This paper outlines some practical aspects(electrical and electronic) of instrumentation system applied for a silica-gel based gas gathering system. This will connect the students who are studying courses on and the professionals in the field of instrumentation and control engineering.

Keywords*: Transducer, Signal conditioning, Calibration.*

1. Introduction

An instrumentation system is an aggregation or assembly of devices united by some form of regular interaction of an interdependence. It is a group of diverse units or devices so combined by nature or by a n art to form an integral whole, and to function, operate or move in unison, and often in obedience to some form of control. Electrical and electronic instrumentation for a natural gas process(silica-gel based) plant may be consists of both analog and digital types of instruments. Analog systems deal with information in analog form. An analog signal may be defined as continuous function such as a plot of voltage versus time or displacement versus force. On the contrary, digital instrumentation systems deal with information in digital form. A digital quantity may consists of a number of discrete or discontinuous pulses whose time relationship contains information about the magnitude and the nature of the quantity under measurement.
An analog system typically consists of some or all of the following elements: (a) Transducers: Thermocouples, Strain gauge bridges, piezo-electric devices (b) Signal Conditioning Equipment: devices for amplifying, refining or filtering, isolation, linearization or selecting certain positions of signals (c) Multiplexer (d) Calibrating equipment (e) Integrating equipment (f) Visual display devices (g) Analog recorders (h) Analog computers.
A digital system typically consists of some or all of the following elements: (a) Transducers (b) Signal conditioning equipment (c) Multiplexer (d) Signal converter (e) Analog to digital (A/D) Converter (f) Auxiliary equipment (g)Digital recorder (h) Digital Printer.

2. Needs Analysis

An instrumentation system in industrial applications measures quantities such as temperature, pressure, force, flow, humidity, light intensity, etc., and controls certain elements in the system to maintain the measured quantity at some desired value. By a proper instrumentation system we want to control the operating conditions of the gas process plant as per requirements such as: the ratio of material flows, the correct temperatures (heaters, dehydration towers), pressures (inlet and outlet temperatures of separators, well head pressures), fluid levels. The prime element (mechanical, electrical, magnetic or a combination of two or more of these devices)of a measurement system is a sensor. Sensors producing electrical outputs in the form of voltage, current, charge, resistance or capacitance are most commonly used because the electrical outputs can be easily amplified, conditioned, modified, processed and recorded. Electrical signals enable remote measurement too. However, we can classify our needs for instrumentation into the following categories:
Measurement: measures and detects various parameters in the field area

Control/Switching: how much to open/close the valves or to control the operating conditions
Indication: in the control panel, starting from inlet (wellhead) values to the sales condition
Alarming/Shutdown: in the annunciator panel, any unusual/abnormal condition.

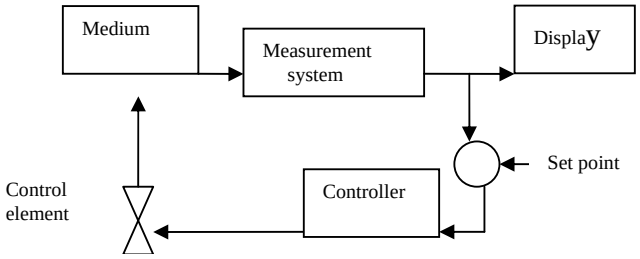

Fig.1 Block diagram of a generalized instrumentation system.

3. Pressure and DP Measuring Device

Electrical type pressure sensors use elastic elements to sense pressure and use different types of sensors to measure changes occurring in sensing elements. Pressure and differential pressure devices are so constructed that increasing or decreasing pressures produce linear movements on pointers or dials which move over calibrated scales. At the same time that they provide a local indication, they may also provide a movement to a flapper in a flapper-nozzle relationship to give a proportional output signal for remote use. The same principle applies to filled temperature systems where the pressure of constant volume systems changes with the contraction and expansion of the fluid in the system. Indication or transmission of these measured values is accomplished primarily by balancing systems commonly referred to as motion-balance or force-balance systems.

Electronic Force-balance Transmitter

The electronic force-balance transmitter is similar to its pneumatic counterpart. The flapper and nozzle arrangement is replaced with some type of electrical detector, often a coil whose inductive reactance is modified by the proximity of the beam. Electronic amplifiers (normally transistorized or with integrated circuits) convert the detected signal to a DC current which serves as the transmitted signal. The feedback force generated by the process variable (as in the pneumatic system) is provided by the output signal and is used to counterbalance the force generated by the process variable. The span of the transmitter is changed by simply adjusting the position of the beams fulcrum. Range adjustments of 10:1 are typical for force balance transmitters. The level gauges attached with various separators (inlet separator) are designed in accordance with the principle of force balance.

4. Flow Measurement

Positive displacement meter or turbine flow meter can be used as volumetric measuring flow meter. The flow of fluid engages the blades of the rotor, causing the rotor to rotate at an angular velocity directly proportional to the velocity of the fluid. Because the meter has a finite volume, the angular velocity is directly proportional to volume flow rate. As the rotor blades pass beneath the pickup coil, the change in magnetic flux causes an AC electrical signal to be generated. The frequency of the sinusoidal waveform generated is directly proportional to total volume throughput. Positive displacement meters or turbine flow meters can be converted to mass flow meters using a gas density transducer and a simple readout system (e.g. flow computer). Since both the flow meter and density sensor signals are in frequency form, the readout system need use only digital techniques.

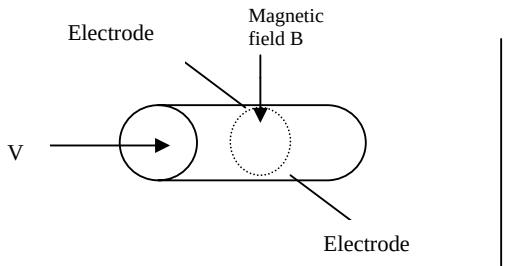

Fig.2 Electromagnetic flowmeter--Principles

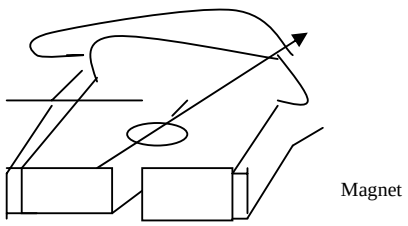

Fig.3 D'Arsonval Galvanometer to Calibrate DP & PT

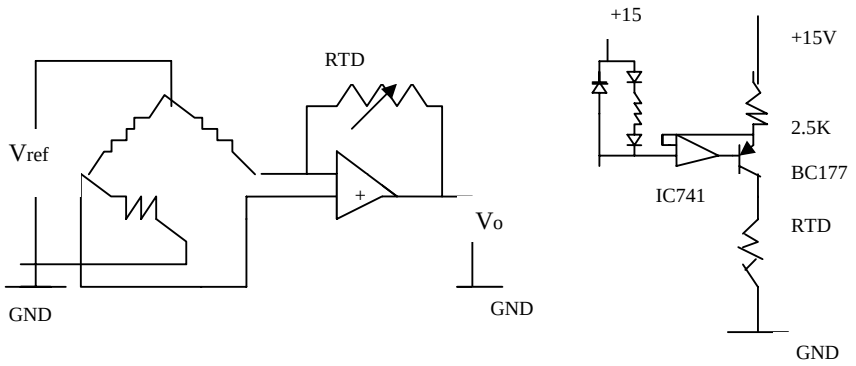

Fig. 4 Temperature Measurement Circuit using RTD: (a) Bridge Circuit (b)Current Source

5. Temperature Measurement and Signal Conditioning

Several types of temperature sensors are available to measure temperature. The thermocouple, resistance temperature detector (RTD), and thermistor are a few widely used types. The RTD changes its resistance with temperature. By measuring the change in resistance exhibited by the RTD, the temperature of a medium is measured. RTD is used in gas process and condensate recovery plant for measuring the temperature of inlet heater, regeneration gas heater (hot oil temperature) etc. Somewhere bi-metallic thermometer is used (desiccant tower outlet temp.). Signal-conditioning provides operations necessary to transform a sensor output into a form and level necessary to interface with other modules of the measurement system. The output signal from sensor is usually very low in level, weak in power, and easily susceptible to electromagnetic noise. It requires amplification with large gain and little noise and distortion. Common signal-conditioning operations are: amplification, isolation, filtering, scaling, attenuation, current to voltage /voltage to current conversion. Signal conditioner for RTD or thermistor uses a simple bridge amplifier to convert the change in resistance to a proportional voltage. The signal- conditioner for the RTD and thermistor, supply the required ac/dc voltage /current excitation for the bridge circuit.

Signal Processing Simple signal-conditioning is not sufficient in many measurements. In addition to signal conditioning, further processing by signal processing circuits such as modifiers, detectors or demodulators are needed before they are displayed. Phase sensitive detectors, peak detectors, RMS converters, comparators, voltage to current converters, current to voltage converters, voltage to frequency converters, frequency to voltage converters, and logarithmic amplifiers are a few signal processing circuits that are built-in in a measurement system.

6. Calibrating Equipment

Analogue indication of electrical parameters such as current, voltage, resistance (converted to current or voltage by a bridge or other such circuits), etc. is carried out by an appropriate adaptive version of D'Arsonval Galvanometer—so named after its inventor. The aluminium frame is pivoted and provided with spiral suspension and control springs. A pointer is attached to the coil. The current passing through the coil produces a rotating movement of the coil and this angular deflection of the coil is directly proportional to the current. As the electric signals used on the plant are limited to 4--20mA, this meter can measure current within the range of 4—20mA. The flow is cut before calibration of transmitters. Then pressure input is arranged by using a calibrator which is converted into current signal within the range. By comparing the spot response with the remote (control room) response, necessary change is performed and accuracy is made.

7. Other Instruments

So far the fundamental functions of any control loop have been listed and discussed. In almost all control loops, one or several other functions are used. These include recorders, indicators, transducers or converters, integrators, alarm and shut down functions.

Indicators: These are electronic indicators observed from the control room. For monitoring various parameters of the process, these electronic indicators are used that present measured variables in numerical form, bar-graphical form etc.

Recorders provide continuous records of measured variables with respect to time. For recording the temperature or other parameters of the desiccant towers, electronic recorders are used. Most charts are driven electrically, but mechanically and pneumatically driven charts are also available.

Transducers or Converters: The development of miniature electronic controllers in the early 1950's created a need for a group of instrument devices –transducers or converters—whose use continues to grow. Their main purpose is to convert signals from one energy form to another or from one signal level to another. Gas density transducer, displacement transducer, and many other types of transducers may be used in a gas process plant.

Electronic Transmitters and controllers were introduced about the same time. Because at that time there were no electronically actuated valves (final control element) available, a transducer was necessary to convert the electronic signal to the pneumatic signal needed at the valve.

Integrators are instruments that receive continuous rate signals (either pneumatic or electronic) and automatically provide running totals or integrated values of these rates. They are used primarily for flow measurement. Units are available with six-digit or eight-digit counters normally and may or may not have reset functions. Integrators may also be provided with other functions such as switching so that when a pre-determined value is reached, initiation of appropriate actions occur (such as valve closures or pump shutdowns).

8. Alarm and/or Shutdown Functions

Ordinarily an alarm condition is one that warns that a shutdown may be imminent. Conversely, a shutdown is a situation in which an alarm condition existed that was so serious that no time was available for remedial action. There are instances when time existed for remedial action, but some reason the action is not taken. In either case, a switching action occurs to initiate the alarm or shutdown. The switch, in this case, is a device which "measures " the variable at a particular value and operates(opens or closes) when the preset value is reached.

Switches which actuate alarms or shutdowns may be piped directly to the process (process actuated), or they may be actuated by transmitted signals. Many companies insist that shutdown functions be initiated directly by process mounted devices rather than secondary (transmitted signal) devices. A typical application of pressure switch used on pneumatic signal lines and is applicable to whatever variable the system is measuring—flow, pressure, level or other.

Alarms units which provide the visual alarm indication include units such as light or it may be part or a multi unit system. The devices and equipment that may be shutdown include pumps, compressors and other types of rotating machinery that could be damaged under adverse operating conditions. Solenoid valves may be operated to open or close piping and equipment systems for safety precautions, for material conservation, to maintain product quality or for some other economic consideration.

9. Effectiveness Influenced by Electric Instrumentation

It is important to make a comprehensive survey to ascertain the types of measurements and learn the good and bad features of each of these types. Only then will one be aware of the best method for a particular application. For measuring flow, positive displacement meter method provides continuous measurement, high accuracy and resolution, fast response and intrinsically safe etc. advantages. On the other hand, for economy, for product quality, for equipment and personnel safety and for the reduction of losses, the best level measuring technique is essential. Furthermore, for remote indication, recording or control, electrical type level measurement method is preferred. Pressure transducers are mechanical, electrical or electronic types. Electrical type pressure sensors use elastic elements to sense pressure and use different types of sensors to measure changes occurring in sensing elements. Thus electrical instrumentation is more advantageous than the others.

10. Conclusion

This article provides a general discussion on instrumentation for a natural gas process plant. However, this is an introduction to the complex field of instrumentation engineering keeping in mind that once the fundamental concept is properly understood, a student or a fresh graduate will be able to understand and operate more complex system; therefore, find out the update technology and improve where necessary.

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