REAL TIME ELECTRONIC GAS MEASUREMENT

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Introduction

For many years now, flow computers have been implemented in gas measurement systems to utilize technology, to improve measurement accuracy, provide far more efficient data acquisition, and provide better control resources for remote interface through telemetry.

As the meter's functionality has increased, the meter technician has had to become more diverse in his or her knowledge of measurement, control, computers, and electronics. By taking a closer look at the various advanced applications and reviewing the basics, hopefully the technician will have a better understanding of the requirements of handling, installing, and working with today's advanced flow computers.

History

Early on, the flow computer simply interfaced with the three primary inputs required for gas measurement and duplicated the 3-pen chart recorder's measurements, but with improved accuracy and response.

Primary Meters

This data was also stored in a periodical database for retrieval and recalculation should the need arise. Differential pressure, static line pressure, and the meter temperature were typically acquired from an analog 4-20 ma transmitter or 1-5 volts and were read into the flow equation. These devices had to typically be bench-calibrated and spanned using test equipment and electronic meters and power supplies. The device was usually spanned to a range required for the particular application and matched to an appropriate electronic signal such as 4 ma for zero, and 20 ma for full span. Once the devices were bench-calibrated, they were taken to the field and installed on the meter and then matched or calibrated to the electronics of the meter so that 0 read 0 in the meter and full span or 100% read 100% in the meter. This calibration was then recorded in the Meter history for archive purposes.

As technology improved, the sensors advanced to smart sensors that could digitally convert the actual pressure or temperature measurements to a signal that could be read by the microprocessor-based flow computer. These devices are still “calibrated" and matched to the flow computer to validate the accuracy and stability of the inputs for the flow calculation.

Measurement inputs were only the beginning of the vast array of input/output signals to be used at measurement locations. As the usefulness of these devices gained speed, it became clear of the additional horsepower of the flow computer and its ability to perform additional tasks.

With the desire to do more, additional I/O was required. Not only did the meter move from “simple to understand” analog inputs, but also there were now digital RS485 multi-drop communications to highly accurate multivariable sensors. These are typical of most modern flow computers. The digital communications read and write data to the highly accurate and stable transmitters and new methods of verifying and troubleshooting these devices had to be acquired.

No longer just measuring a voltage would be enough. Digital communications require a bit more sophistication to diagnose and troubleshoot. Computer software programs greatly aid in reading diagnostics of the device.

Additional inputs from turbine meters and ultrasonic meters can be used to provide frequency pulses to pulse counters and the flow computer would perform the AGA7 calculations and archival of the pulse input data along with the pressure and temperature.

The typical advanced application also uses discrete inputs for device statuses, analog outputs for remote setpoint signals, outputs proportional to flow signals for external devices, and many specialized digital communications to other devices and locations.

With these additional requirements, the flow computer should be expandable to allow for the various I/O requirements. This is typical of, but not limited to, I/O such as discrete inputs, discrete outputs, analog inputs, analog outputs, pulse input counters, RID inputs, thermocouple inputs, RS232 serial communications using protocols such as Modbus or custom protocols, HART protocols, and now even the higher end protocols such as FieldBus Communications as they become critical with higher end applications.

Communication ports must be expanded to include local configuration, local device communications, and SCADA telemetry ports. These communications are many times serial-based and interface to a broad range of devices.
Newer systems are also showing up with network ports for local or wide area communications. Communications from the field to the host SCADA system takes on many faces. From a basic telephone landline dial-up to satellite communications, the speed, frequency, cost, and data load must be considered when determining which path to take.

The technology of communications is changing daily. We now have to choose from systems such as wireless cellular, wireless cellular digital packet data, microburst, spread spectrum radio, and wireless networking to name a few. Hybrids of almost all methods are being mixed together such as using radio clusters connected through serial terminal servers to the company's wide area network.

Timing of communication polls, total system loads and good understanding of the entire communication network must be in place when tackling the integration of the remote sites through telemetry.

*Secondary Measurement
Transmitters and Gas Chromatograph*

As all of these new features are added to the total load of the remote flow computer, one must consider the total power load in sizing the power system. Typically, the basic flow computer takes up the least amount of power.

Communications can be the single greatest power load on the system. The power draw from the communication device must be considered along with the polling load. Many systems have been originally underpowered because they were only going to be polled once per day when in reality the intervals increased to hourly. Other devices and their duty cycle loads on the system must also be taken into consideration when powering these advanced systems.

The biggest culprit to pull down the power system is any type of solenoid or relay that has a coil to be energized.

The key to taking on the challenge of advanced applications is to think about the entire system requirements and the long term effects they will have on the primary application--measurement.

Integration and Education

As the larger and more complex systems are integrated into the measurement system, the level of integration experience and education of the field personnel should be considered.

Many times, the larger and more complex sites may require the use of a system integrator or systems engineer. Their experience with the variety of equipment to be interconnected can save many hours of frustration when implementing these more complex hookups.

If the system is going to be highly integrated into SCADA, a complete understanding of the total system from field device, logic, and overall control goal must be understood and managed. Companies must educate their workforce to keep up with technology. This education must include the proper use of test and measurement equipment, computers, and the many varieties of software, communications equipment, and basic electronics.

Advanced Applications: PID Controller, Flow

The first functionality to consider beyond just measurement is control. This will require either a pre-designed control application such as Proportional Integral Derivative (PID) control or some sort of logic applications. These applications should be readily accessible in a familiar format to allow for configuration, tuning, and input/output assignment. PID Control requires an input process variable, an output to some sort of control device, a means of entering a setpoint, and the ability to tune the application to maximize the ability to control without being unstable. Typically in the measurement world, control is applied to flow or pressure.

Typical Flow Computer Configurations

The input process variable is the actual flow calculation or the differential input from the orifice meter. In the days of the 3-pen recorder, maintaining flow control could reduce differential pen painting and thus improve the accuracy of the measurement. With the introduction of highly accurate flow computers, control is still desirable, but the improved accuracy and frequency response of the differential sensor has lessened the need for flow control for simply improving chart recording.

When configuring a loop for flow control, care must be taken when setting up tuning parameters to allow for the calculation period. Depending upon the method of calculating instantaneous flow, the loop period must take this lag time into consideration. Additionally, the tuning of the PID loop must allow for proper response to process upsets (Proportional Gain) and be fast enough to offset the error and return to setpoint (Integral or Reset).

The response of the control valve and associated interface to electronics must also be considered during the loop tuning.

Closed loop PID control, when configured properly, will allow the controller to monitor error from setpoint and respond to that error with minimal lag time or additional process upset.

PID Controller--Pressure

In addition to flow control, the advanced flow computer may also be called upon to perform pressure control as well. The basic setup is similar to flow control, except the process variable is typically a pressure input from a transmitter. This process is typically much faster in its process updates and the loop must be tuned accordingly.

Tiered PID control is another method of control with today's flow computers. Typically, this method allows for multiple PID configurations to be configured and nested together to allow either a low or high output select to feed additional PID loops or the control valve. This is done in pneumatic controllers with high or low select pneumatic relays. Primary control with override is also a method used by having dual loops configured with logical parameters dictating which loop is in control. In addition to PID control, many times the flow computer is called upon to perform custom logic or run switching or automated nomination control. Similar requirements and user interfaces as with PID control should be in place to accommodate this advanced logic and control. Run switching typically monitors a number of different flow variables, pressure, or some outside input and can switch control valves on or off to add additional metering so as to improve range-ability. The interface here should allow for many inputs and multiple outputs as different runs are added or removed from the metering station (see below).

Control applications can also use the ability for field devices to talk peer to peer. Grid management in a gas distribution system can capitalize on this ability to monitor low pressure points in the system and communicate this data back to the host as well as directly to the district regulator stations also equipped with the computer. By utilizing the remote low pressure site as the process variable, closed loop control can be attained by allowing the district regulator to adjust pressures to compensate for this low pressure point. With the proper programming, these systems can also "learn" how time of day, temperature, and pressure loading effect the system pressure and can predict the needs of the system. This learning process, commonly called Adaptive Predictive Control, has been successfully used in the management of gas distribution systems.

<u>Programming</u>

The standard applications as mentioned previously can be enhanced with custom programming, available in most of today's flow computers. This custom programming can be in the forms of scripted logic, ladder diagrams, or cause and effect applications. Today many offerings of flow computers use the standard IEC – 61131-3 suite of applications incorporating the already mentioned programming styles. The custom applications are either created on the fly with the field device and software or submitted to factory programmers for custom firmware applications that require flash upgrades or chip changes. The flexibility of having on-the-fly programming capabilities greatly enhances the user to be able to create special logic, mathematical, or basic process functions outside of the off-the-shelf functions offered by the flow computer vendor.

One such programming language offered is Function Sequence Table scripted logic programming. This application allows the user to create interacting logic applications in the field using the configuration software. Programs can be written using drop down menus to address the points in the flow computer, math functions can be implemented, and the entire program can be compiled and tested at the field level. Once the desired effect is achieved, the program can be saved and downloaded into other devices. The user interface is typically through register fields accessible with the device software.

Some computers have a custom user display that creates a custom platform of data gathering so the user can access setpoints, values, or make configuration changes on a screen that is very descriptive of data fields and is unique to the custom application (see below).

Host Applications, Acquisition Remote Data

The ability to communicate remotely to the electronic flow computer opens up many possibilities beyond just data gathering. Depending upon the type of communications and frequency of polling the remote device, many options for remote control can be implemented. From simple setpoint changes, to advance logic and emergency shutdown processes, the communication systems links the flow computer and controller to the measurement and gas control office.

Typical SCADA Host Systems

Depending upon the application, the remote logic or control can be implemented during the remote field configuration. This process is usually done either by configuration interface software or downloads of advanced logic or configurations. Once the functionality is in place, the interface to the remote device is implemented over the communication system.

The interface is typically by demand poll and frequency is based upon the capability of the communication method and power available at the remote location to power the communication devices at the desired duty cycle. The palling application usually is set up for scheduled meter history downloads as well as for monitoring system status. These intervals will be adjusted according to the priorities of each site and the required frequency for meter archive trail retrieval as outlined by each company. Typically each meter retains a minimum of 35 days of meter data (required for AGA) archived information. Additionally, the system may also be configured for spontaneous report by exception or cry out. This method of remote communications allows the remote field device to initiate the call back to the host application or to some alarm monitoring system. This call out can be to simply send out time critical data or to announce an alarm condition back to the host for handling. Many times, alarms are handled at the host application with pager or voice notification and sometimes automated email.

Summary

As one can easily come to understand, the widespread use of microprocessor based flow computers has expanded the field capabilities in the areas of data acquisition, remote interface, and control. The units found at today's measurement sites many times are underutilized as a complete solution to remote field measurement and control. By taking the time to understand the capabilities of the various manufacturers' units, learning how to use these features, and implementing them in a planned way, the modern gas company can easily improve operations and ultimately their bottom line performance.

Biography

Jim has been involved with the gas measurement industry for 30+ years and has been with Emerson (previously Bristol Babcock) now Remote Automation Solutions. He has been a member of AGA and API since 1985. Previously involved with the creation of the API 21.1 and AGA white papers. Currently is the Strategic Account Mgr for the North Americas. He has a BSIT degree from Kansas University.