Application of a FOUNDATION Fieldbus System at the Gas-mixing Station of Wuhan Iron and Steel Co.

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Abstract

The COG (Coke Gas) and BFG (Blast Furnace Gas) from iron-making plants are mixed in a gas mixing station according to calorific value required by the users. The MG (Mixed Gas) with stable pressure and calorific value is then supplied to several endusers of Wuhan Iron & Steel Company (WISCO). Due to limitations of the previous control system, fully automatic feedback control was never possible. With Smar’s fieldbus control system, SYSTEM302, however, we took full advantage of the benefits offered by FOUNDATION Fieldbus, such as diagnostics, field control and interoperability, lowered system overall cost, and became the first in China to achieve stable pressure and calorific value control through a “Two-Valve” solution.

Keywords:
Gas-mixing Station, Foundation Fieldbus, Calorific Value

Origin of Control Solution

The following diagram shows the process and control schematics of the No. 2 gas mixing station prior to adopting fieldbus. Its primary goals were

1. To achieve stable pressure for the mixed gas, and
2. To achieve user required caloric value of the mixed gas through automatic flow ratio control between blast furnace gas (BFG) and coke gas (COG).
The original control system employed a “four-valve scheme” (Figure 1). The first two valves were used to control the pressure stability through single PID control prior to gas-mixing. Upon mixing, the BFG valve was used to control mixed gas pressure stability through a single PID. In addition, a fourth valve, the COG valve, was employed to control the flow ratio of BFG and COG in order to achieve the desired caloric value of the mixed gas.

In practice, the COG pressure before mixing is about 20-24kPa and that of BFG 21-25kPa, while the user required mixed gas pressure is at 20±1kPa. Due to throttle components, reducers, line resistance, and valve disks along the gas lines, significant pressure loss occurred, resulting in a differential pressure range of less than 1 kPa across the COG and BFG valves. Since the best domestically made butterfly valves only reach a rangeability of 1:50 and best available global technology only reaches 1:100, at the low differential pressures of around 1 kPa, it was practically never possible to achieve satisfactory overall control through the “four-valve scheme”.

What has helped us overcome this limitation was Foundation Fieldbus technology. Upon investigating this technology, we realized that we could eliminate the first two valves by leveraging the superior control capabilities of Foundation Fieldbus, and thus increase the differential pressure values across the remaining two valves and enhance overall system dynamic range. The resulting “two-valve” solution achieved through a Foundation Fieldbus system, Smar’s System302, is the first-ever such application in China. We not only accomplished fully automatic control for our gas mixing station, but also lowered our system cost and improved our productivity.
Hardware Configuration of Control System

The system has a single workstation with process visualization software and fieldbus H1 interface. Fieldbus intrinsic safety barriers are used to ensure the safety of the system, and a programmable logic controller (PLC) is fitted with a fieldbus module to integrate the data between conventional signals and the fieldbus network, which uses the tree-type topology (Figure 2).

Figure 2. System hardware configuration

Each Fieldbus network has four safety barriers and each barrier connects to 3 or 4 Fieldbus devices. Since our control room is 1.2Km away from the field, we have realized approximately 70% savings on wiring alone as compared with a conventional system.

Since controls and calculations are distributed in transmitters and positioners in the field, the system architecture becomes leaner. And since less hardware is used, large panels and cabinets are no longer necessary. This results in significant savings on control room space.

System Control Strategy

Figure 3 shows the schematic of the pressure cascade control and calorific ratio control without coupling between each other. The dotted lines denote physical fieldbus devices and solid lines function blocks. The lines between devices indicate fieldbus communication links. In our system, controls are completely distributed in the field. So far, we are still the only large mixing station in China to successfully employ the “two-valve” scheme to process 50,000-100,000m³ per hour. Many other major steel
makers still use the “four-valve” split control solutions for similar applications. The main advantage of our solution is that we eliminated the common interference between flow and pressure control by using the Output Selector/Dynamic Limiter (OSDL) function block, thus avoiding system oscillation.

Figure 3. Control strategy

Problems and Solutions During Engineering

Commissioning

1. Achieving Interoperability
Interoperability is an important feature of Foundation Fieldbus. We have successfully achieved both device and host interoperability, which are demonstrated by the seamless communication of PV from Smar transmitters to Fisher valve positioners, and by the host’s correct interpretation of data from devices of a different manufacturer.

Two key technologies make Foundation Fieldbus interoperability possible: function blocks and device description (DD). We followed the procedure below to achieve interoperability:

(1) We first copied the Fisher valve positioner DD to the host DD directory.
(2) We then adjusted the setting of relevant files according the following details:
   (a) Adding the following items in 070101.cff:
       MaximumNumber of linkage objects = 50
       MinimumNumber of linkage objects = 2
(b) Adding the following lines in standard.ini:

```
005100 fisher
[005100 device by code ]:fisher device types
5400 = DVC.5000f
005100 5400 07 01 80020310 = RES
005100 5400 07 01 80020530 = TRD
005100 5400 07 01 800201F0 = AO
005100 5400 07 01 800202B0= PID
```

Finally, Interoperability between Smar transmitters and Fisher valve positioners is verified by performing function block link checks.

2. Improving system update time

There are a total of 16 fieldbus devices on two fieldbus segments. Although the Foundation recommends a maximum number of 16 devices per segment, we found that, for our particular application, a reduced number of devices are more appropriate in order to have faster response time, because we have complex control strategies and a large number of communication links. Thanks to the engineering tool, we could calculate the macrocycle of each segment and allocate the appropriate number of devices. By placing 11 devices that are more closely related on one segment and 5 devices on the other, we reached a system update time of 1 second, satisfying our control requirement.

3. Tuning System Parameters

At the beginning of system commissioning, the valve showed a 10% oscillation. The stability of control was also less than satisfactory. We were able to take full advantage of the power of advanced diagnostics offered by Foundation fieldbus to pinpoint the following causes:

(a) The positioning servo PID interacted with the control loop PID, giving rise to valve oscillation;

(b) The low time constant of flow damping contributed to system instability;

(c) The coupling of flow and pressure control caused loop oscillation;

(d) Unstable end-user consumption of the mixed gas often upset the system;

(e) Fluctuation of the compressor output pressure, or valve back pressure, made the valve unstable.

Three counter-measures were then taken to correct these problems:

(a) From the system via the engineering tool, we could remotely monitor the internal operation of the valve positioner and fine-tune the positioning servo PID to its optimal performance. And this performance analysis is only possible through fieldbus.
(b) We increased the flow damping time to enhance system stability.
(c) By tuning the flow and pressure control parameters, we decoupled the loop interactions and eliminated loop oscillations.

Through these measures, we brought the system to optimal stability, achieving mixed gas pressure error of ±0.3kPa and calorific value error of ±0.044MJ/m³. These results far exceed our expectations.

Advantages of Foundation Fieldbus Technology

Fieldbus technology is the extension of digital networking to field devices. And totally distributed field control and openness, among others, are two of the most important characteristics of this technology. Along with these characteristics come drastic reductions in hardware and increased information from the field are available, all of which boil down to short and long term system cost savings never possible in DCS or PLC systems. We think that function blocks are a main vehicle to bring about the benefits of the Foundation technology. There are three classes of Foundation blocks that perform various system tasks:

(a) Transducer blocks and resource blocks;
(b) I/O blocks such as AI, AO, DI, DO, MAI, MAO, MDI, MDO, etc;
(c) Calculation blocks such as PID, ARTH, TOT, ISEL, OSDL, CHAR, SPLT, AALM, TIME, LLAG, etc.

Each function block contains scores of parameters that form the basis of device information. The parameters can be classified according to their functionality into several categories: host, process variable, calibration and tuning, diagnostics and alarms, and asset management and records. A parameter in a fieldbus system not only has a value, but also a status to indicate whether the value is “good”, “bad” or “uncertain”. If it is “bad”, the system will not use the value, but instead initiate built-in or preconfigured safety measures. Each status can be further divided into several sub-statuses such as sensor failure, override range, communication error, and invalid configuration. It is this dramatically increased information from the field that enables comprehensive system diagnostics and asset management, which were not possible in conventional systems. Diagnostics and asset management are what benefit the users the most by lowering system operating costs and improved system reliability and availability.

For example, the transducer block on a fieldbus valve positioner contains a parameter that indicates the actual valve position and shows up on the operator display along side the desired valve position. In a conventional system, if you want to have actual position feedback, you need an extra cable and I/O points. In addition, a valve positioner transducer block includes a valve positioning servo loop tuning parameter. This parameter allows the operator to remotely fine-tune the valve from the work station.
Several additional parameters, such as characterization selector and automatic calibration, make system commissioning and operation easier.

Various diagnostic parameters, depending on the device type, are displayed on the workstations. Although we have only utilized a portion of the parameters available so far, we have already seen the benefits they bring. By further understanding these parameters, we believe we still have a lot of room to make the system more powerful.

Another advantage of Fieldbus is the live-list feature. Fieldbus devices are automatically displayed on configuration screen when they are connected. We no longer need to cross-check each pair of wires for the field devices as we did in a conventional system. We don’t need to waste any time checking the devices that appear on the live-list, but only need to focus on those that don’t.

Modularity of a fieldbus system is yet another great feature that we have benefited from. We started with Station No. 2 and have expanded the fieldbus system to cover Station No. 4 by simply adding another segment to a spare port and making some configuration changes. Our plan is to gradually add devices and interfaces to upgrade all of our seven stations to Fieldbus.

From the standpoint of our application, we did notice a few limitations. 100 MB HSE was not yet completely ready at the time we implemented our first two stations. This feature will be a must as we expand our system. The limited choice of discrete devices for use in IS applications is another problem. Interoperability was more complicated then we expected and we’d like to see true plug-and-play interoperability in the future.

To summarize, while we realized significant wiring savings, we feel that this is only the most obvious saving that a Fieldbus system brings. What truly benefits the users for many years to come are diagnostics and asset management.