Woodward Gas Fuel Control System for DLE Turbines

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1. General Information

Woodward Governor Company has developed a new control system architecture for large industrial gas turbines. The core product for the control system is the SonicFlo™ gas fuel control valve (GFCV) that generates higher accuracy performance than conventional valve systems.

This control system is designed for use on DLE (dry low-emissions) technology turbines and is based on the company's extensive experience with fuel control systems for aeroderivative gas turbine control and DLE control theory. The components within the system have a high reputation with both domestic and overseas gas turbine manufacturers, who have applied this system due to its high performance, compact design and low cost. As a supplier of fuel control valves, electronic controls and combustion systems, Woodward is able to optimize these systems and interactions to increase accuracy and reliable while at the same time lowering the total system cost.

2. Background

Highly accurate fuel control is required to control a DLE gas turbine (aeroderivative or large industrial gas turbine) with a multi-stage burner. However, it is difficult to get the fuel flow accuracy and responsiveness demanded by these turbines using conventional fuel flow meter feedback systems. In support of this market need, over a decade ago Woodward developed aeroderivative fuel systems and control methods that sense fuel temperature and fuel pressure of the metering valves in real-time. The control calculates real gas flow in a digital control unit incorporating high-speed processors and sends control signals to the fuel valves to maintain accurate control of mass flow. More recently, Woodward has leveraged this system experience along with the development of the SonicFlo™ fuel system to offer a more advanced method of control that is targeted for use on large industrial gas turbines.
The SonicFlo™ valve improves fuel flow accuracy and responsiveness by creating a choked flow condition that reduces the flow rate to a function of inlet pressure and inlet temperature.

3. System outline

Woodward is able to supply fuel control systems that control DLE burners, from single stage up to five stages. The figure shown below is the four-outlet, parallel fuel delivery system with higher metering accuracy.

The main components for the system consist of four key products. These components can be supplied individually, depending on customer requirements and specifications.

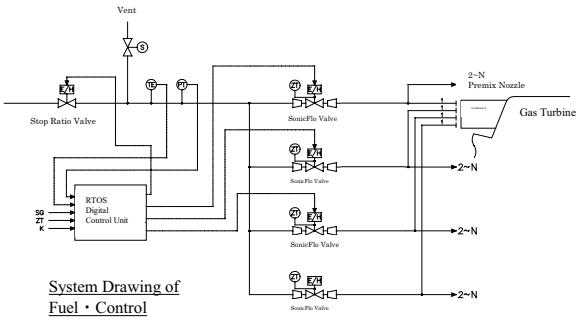

Fig. 1

* MicroNet digital control (gas turbine controller)
* SRV stop-ratio valve (combined pressure control and shut-off valve)
* SonicFlo™ GFCV valves (metering valve)
* Lean pre-mixing nozzle

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4. Specifications of each component

* MicroNet digital control

Woodward's MicroNet control is a digital control incorporating a Real-Time Operation System (RTOS). The MicroNet performs general turbine control - including inlet guide vane control, variable stator control, air bleed valve control, accessory control and sequence control - as well as gas turbine fuel control. To provide accurate, high-speed control, the MicroNet digital control uses a deterministic operational rate control strategy, which defines the required operational speed of each task into rate group categories (some as fast as five milliseconds), corresponding to task urgency level. This flexible control is designed for use on gas turbines and can be applied on many different system configurations with proven software functionality that is designed for the latest gas turbines.

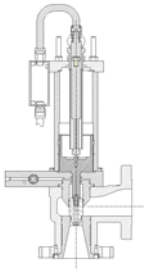
* SonicFlo™ GFCV

The SonicFlo™ valve is a compact, high accuracy gas fuel control valve that is a key component in the total control system architecture. The SonicFlo™ valve includes the valve, hydraulic actuator, servo valve, filter, trip valve and LVDT (linear variable differential transformer). This integrated package reduces error and variability by eliminating linkages and connections between the actuator and valve. Reliability and accuracy of the system are increased by using a triple coil servo-valve and dual LVDT for position sensing. The most significant feature of SonicFlo™ valve is that the valve can maintain choked flow at outlet/inlet pressure ratios of up to 0.8. Choked flow is characterized by flow speeds of Mach number 1 at the control region of the valve. This feature makes fuel flow control possible without effects from changes in the control valve outlet pressure.

This means fuel flow is determined only by the fuel control valve inlet pressure and inlet temperature which increases the overall accuracy of the system by reducing measurement error between multiple pressure sensors. This also simplifies the system design which results in lower cost.

It has been commonly accepted that the outlet/inlet pressure ratio should be limited to less than 0.53 to maintain choked flow on a conventional globe valve. The SonicFlo™ valve guarantees the choked flow operation at outlet/inlet pressure ratios up to 0.8 by applying a pressure recovery sleeve to the outlet of 90-degree angle valve. The practical outlet/inlet pressure ratio of this valve exceeds 0.8, and with high-recovery versions of this valve the pressure ratio can reach up to 0.9.

There are two standard valve flow curves; "linear" and "modified equal percentage". Modified equal percentage curve is made of combining two flow characteristics, one is equal percentage characteristics for higher resolution at the low flow region for reliable and accurate starting and the second is linear characteristic for simpler control at the medium and high flow regions of the valve.



Cutaway view
GFCV-SonicFlo™

Fig. 2

* SRV stop ratio valve

The SRV stop ratio valve is normally installed upstream of the SonicFlo™ GFCV valves, and acts as both a pressure control valve and as an ANSI class 6 shut-off valve, reducing the number of components.

* Lean pre-mixing nozzle

Lean pre-mixing nozzle injects fuel metered by a fuel control valve into the burner.

5. Conclusion

The design of the Woodward gas turbine control system achieves significantly higher accuracy and performance for fuel metering and control at a low system cost than conventional systems. The SonicFlo™ valve design integrates the valve and actuator into a compact assembly which improves accuracy and repeatability. This close integration allows for lower cost, smaller envelope and better re
peatability. As turbines continue to require better performance from the fuel and control system, Woodward is working to offer solutions which integrate proven components and robust designs.