Letting off steam

Bob Beveridge, Emerson Process Management, US, and Lemuel Mixon, Eastman Chemical Co., US, reveal how new model-based technology can improve steam temperature control.

Figure 1. Eastman Chemical Co.'s Kingsport, Tennessee, manufacturing site.

There has been a lot of discussion lately about how power generators are diversifying their energy portfolios through the addition of renewable energy sources. As such, it may be easy to lose sight of the fact that coal still is – and will continue to be – a major source for power producers worldwide. According to the World Coal Association, coal has been the fastest-growing fuel in recent years and today generates 41% of the world's electricity.[1]

Coal-fired plants typically operate for several decades. Unsurprisingly, over the lifespan of a boiler and turbine, a number of factors can impact plant processes and overall plant performance. For example, variations in steam temperature and the resulting stress on boiler pressure parts can harm boiler and turbine components, causing operational efficiency to falter. Further, because fuel is required to heat steam, and energy is lost when cooling steam, running a unit inefficiently can increase fuel costs.

By improving steam temperature control, it is possible to reduce boiler tube leaks and turbine blade fatigue, thereby significantly decreasing maintenance costs and outage requirements. Stabilising steam temperature also improves ramp rates, which further contributes to increased revenue.

The bottom line: quickly and efficiently stabilising steam temperature can help boost overall plant efficiency and longevity. Of course, this is easier said than done, and there are a number of challenges to minimising steam temperature variations. They include:

- Identifying optimal co-ordination between spray valves, pass dampers and tilt devices for precise control and balancing side-to-side steam temperature.
- Determining the most efficient control of superheaters and reheaters to reach design temperature criteria.
- Ensuring even heat distribution to reduce tube leak outages.

Emerson Process Management has developed a patent-pending, model-based control application for users of its Ovation™ control system that provides a measurable improvement in the stability and accuracy of steam temperature control for power generating units. This model-based steam temperature control application has been running at Eastman Chemical Co.'s Tennessee operations since April 2011 and is also currently being implemented at a large coal-fired power plant in the US. A closer look at the Tennessee installation illustrates the benefits of this new technology.

Located in Kingsport, the Tennessee operations form one of the largest chemical manufacturing sites in North America. Its size and scope are impressive: roughly 7000 of Eastman's 10,000 employees work at the

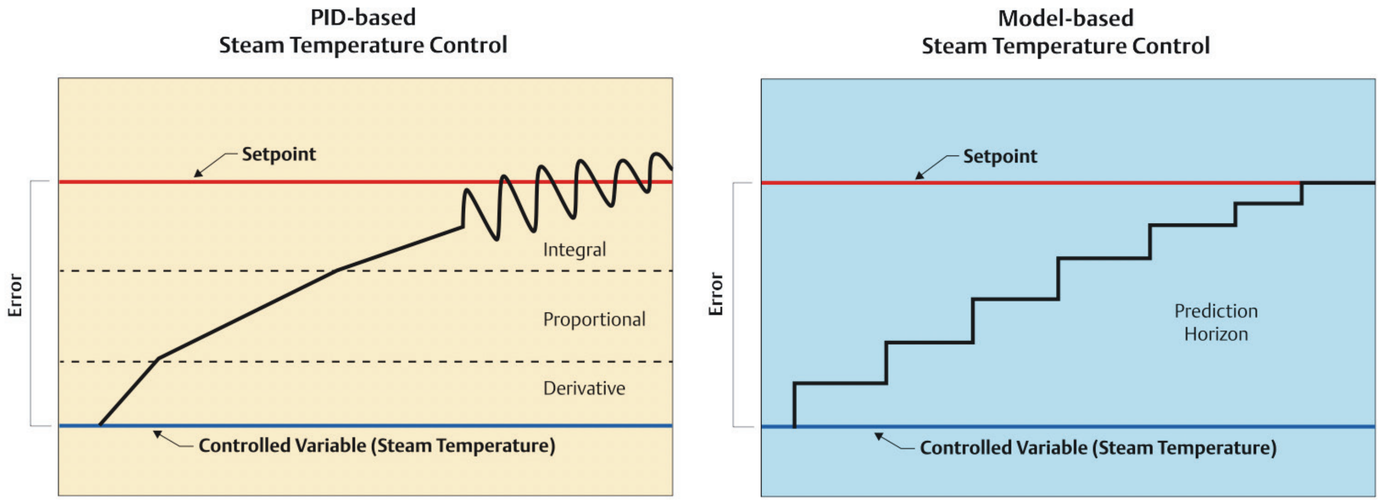

Figure 2. These graphs depict the differences in how a PID and model-based technology adjust a manipulated variable to reach setpoint. The PID uses predetermined proportional, integral and derivative variables whereas the predictable, step-response of the model-based technology adjusts the manipulated variable more quickly, efficiently and accurately to achieve targeted setpoint.

Kingsport site, where there are more than 550 buildings on approximately 1600 ha. (4000 acres) of land. The site uses about 160,000 kW of electricity on average and has 196,000 kW of installed generating capacity – enough to serve approximately 170,000 average homes. Four onsite cogeneration plants produce the steam necessary to feed the chemical processes, while the electricity is used to power the onsite buildings.

At the Kingsport cogeneration plant, the Ovation model-based application for steam temperature control was applied to Boiler 31, a Riley wall-fired boiler with low NOx capability and a generation capacity of roughly 16 – 18 MW. The boiler, the first of its kind when it went into service in 1994, has good maneuverability and is therefore often called upon to quickly ramp up to produce additional steam to meet increased demand from the adjacent chemical processes.

Stabilising steam temperature on this particular boiler was difficult when the unit ramped up and down quickly. Turbine life was a concern, as steam temperature instability not only causes wear and tear on the boiler tubes and turbine blades, but also excessive movement of the spray valves that are used to cool the steam before it enters the final super-heat stage. In addition to causing rapid valve deterioration and wear, excessive valve movement also contributes to final temperature instability. There was also a concern that significant temperature excursions below setpoint could cause saturated steam to enter into the turbine, resulting in debilitating equipment damage.

Looking for ways to reduce steam temperature variability, the plant consulted Emerson. The company's Ovation control system was already being used to monitor and control vital equipment and processes at this cogeneration facility. Emerson implemented its Ovation model-based application for steam temperature control, part of a suite of advanced, integrated solutions.

This model-based application regulates temperature variations through the development of steam temperature process models. More specifically, application-specific algorithms are used to execute a step-response model that accurately reflects the relationships of controlled variables (a process variable that is to be driven to a particular setpoint, such as final steam temperature), manipulated variables (a signal or device that may be moved to achieve setpoint, such as a spray valve) and disturbance variables (a signal that has an impact on the process such as fuel quality, load or sootblowing) to quickly and accurately achieve temperature setpoint. The overall goal is to provide precise optimal control of the boiler temperature by providing predictive control of changes in the heat release due to load, fuel BTU quality, radiant energy absorption, pass dampers, burner tilt and spray valve performance.

By considering current plant operating constraints and response factors, the model provides optimal results over the dispatchable range of load and operational characteristics. This technology has the ability to dynamically control processes, even while the plant is moving through load ranges. The Ovation model-based steam temperature application runs in a specific loop execution cycle based on process-developed criteria and is fully integrated as a new mode of operation within the Ovation control system. This technology, for which Emerson is seeking three patents, supersedes conventional PID-based strategies, which offer a less accurate, linear response to reaching setpoint (Figure 2).

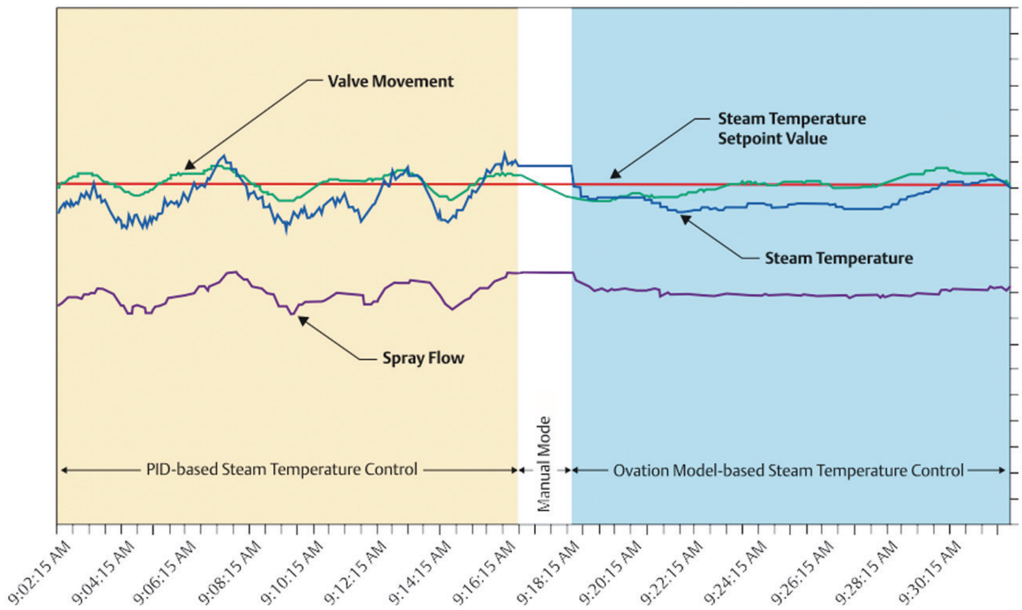

Figure 3. When the plant switched from PID-based steam temperature control to the Ovation model-based steam temperature control application at the Kingsport cogeneration plant, the results were immediate. The predictable step-response of the model-based technology adjusted the steam temperature more quickly, efficiently and accurately to achieve targeted setpoint.

The project at the Tennessee plant launched in 2010. Operators provided input to Emerson regarding the operating range of the boiler. This was followed by valve tests to check for seat erosion and to obtain flow characterisation for linearisation. The results of this testing gave Emerson the data necessary to build a model for the steam valve movement's effect on steam temperature. The models were successfully installed and tested, and have been running since April 2011.

The plant saw immediate improvements in steady-state operation, including the ability to quickly and accurately reach setpoint, and then maintain operation at the desired temperature. With the model running, the plant has seen a 55% improvement in standard deviation of temperature versus setpoint (3.43 to 1.55), as well as a nearly 53% improvement in standard deviation of spray flow and valve movement (9.9 to 4.7) (Figure 3).

The plant had also been concerned about the potential for equipment damage due to saturated steam entering into the turbine when it ran too far below the steam temperature setpoint. This concern was addressed through the saturation protection component of the model-based steam temperature application: on superheat loops, steam saturation priority-lower signals are integrated into the control logic, protecting against the introduction of saturated steam into the turbine.

Plant operators are amazed at the results to date, and are continuing to benchmark the unit's performance to further illustrate a rapid return on investment of the steam temperature control application. Comparing plant performance before and after installation of the technology over an extended period of time is expected to demonstrate that the plant will experience improvements in operational efficiency. In the long term, it is also expected that the improvement in steam temperature stability will reduce thermal stress, and subsequently help extend the life of the unit. WC

References

1. Coal statistics, World Coal Association www.worldcoal.org