ACSI's Model-Based Controller Maximizes Performance in Glass Forehearths

Fast, accurate response to temperature variation improves production and quality

ACSI's model-based controller (MPC) is outperforming PID controls in glass forehearth applications. The ACSI-integrated process controller is able to minimize job change time and react quickly to stabilize temperature variations.

Opportunities for Improved Process Control

Controlling glass temperature is key to achieving optimum glass viscosity and gob weight. Temperature variations as slight as one degree or less can negatively impact the quality of the finished product and result in lost production time. Job change time and zone temperature modeling offer opportunities for tighter control

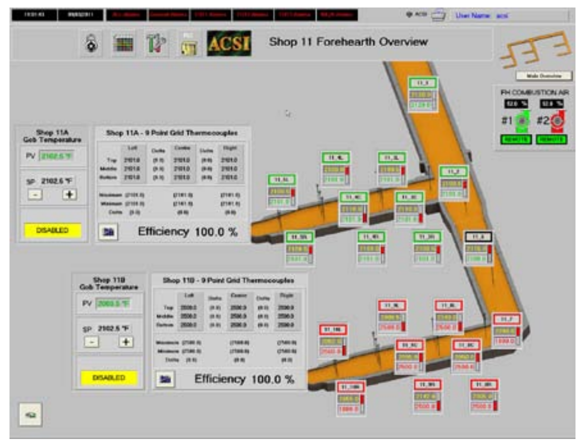
What is Model Predictive Control?

Predictive Controller

- Model learns process function, looks at the reactions, and then learns what adjustments are needed to avoid disturbance
- ACSI model-based controller can predict control actions required to stabilize the glass forming process.

Feed Forward Input

- Control system models feedforward inputs and updates control actions to quickly stabilize temperature variation. Signals are fed forward into the control model to provide advanced warning of process upsets. The model can then make the necessary changes before the upset reaches the local zone, and in most cases, it can completely eliminate the upset before it is sensed by the local zone.



Model-Based Control is Predictive and Adaptive

The ACSI model-based controller is effective in controlling job change and zone temperatures by modeling the existing process. The controller creates models for each control/process variable and feed forward input. These ideal models allow the system to anticipate changes needed to maintain consistent glass temperature.

Once the optimum process is modeled, the ACSI model-based controller can:

- predict control actions required to drive the glass temperature to set point quickly without overshoot
- adapt to process and production rate changes automatically for better control without loop tuning
- model feed forward inputs and update control actions to quickly stabilize temperature variation

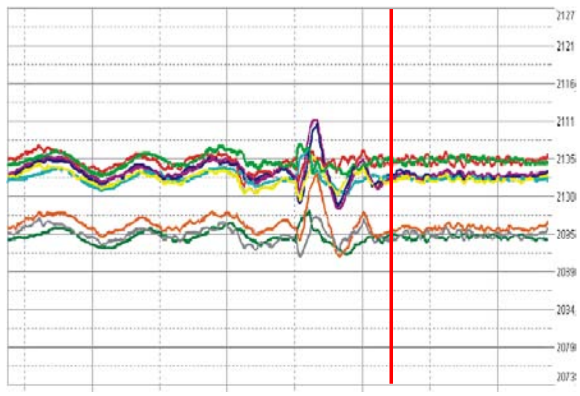
Job Change Time

In order to maximize profit potential, it is essential to minimize job change time. This requires achieving new glass temperature set points as quickly as possible with minimum overshoot. It is difficult to achieve both these objectives simultaneously with a standard PID controller. One of two scenarios is likely to occur: 1) glass temperature can be raised quickly, but the temperature overshoots the optimum set point and must be adjusted back to the set point; or 2) glass temperature is achieved with a gradual rise in temperature that requires a long time to reach the set point. Either scenario typically requires several hours to stabilize glass temperature during which production operates at less than optimal parameters.

Zone Temperature Modeling

Traditional forehearth design places a sensor at the exit outlet of each forehearth zone to measure glass temperature as it exits the zone. The sensor relays data to the PID controller which adjusts the heat to bring the glass temperature back to set point. As the molten glass travels through each forehearth chamber, respective controllers continue to "play catch up". The recovery time for this process may be long and during recovery production values decrease.

Nine Point Grid Before and After MBC

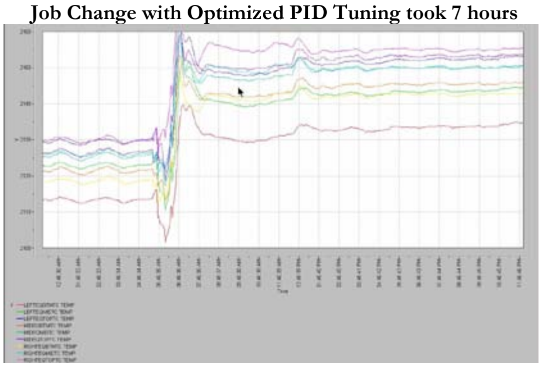


When integrated as part of a comprehensive control system, the ACSI model-based controller delivers the following production and quality benefits:

Benefits	**Actual Customer Results**
• Reduced variability of gob temperature	300% reduction in gob temperature variation
• Improved temperature stability	2% improvement in Pack
• Faster compliance to setpoint changes	Reduced job change time 7hrs to 2-3 hrs
• Faster recovery from disturbances	50% less time to achieve stability

The two figures below show the 9-point grid temperatures during job changes. These two forehearths are essentially equal to one another in size, tonnage, and pull rate, and the same setpoint changes have been made. The results are dramatic and show the ability of Model Based Control to quickly stabilize the temperature during job change, thereby minimizing the time it takes to return to steady operation.

Job Change with Optimized PID Tuning took 7 hours



Job Change with Model Based Control took 3 hours