

# How Precise Power Control in a Glass Furnace Saves Platinum Electrodes

*By Spectrum Controls, Inc.*



A key element of optimizing electrical current flow in a glass furnace is monitoring the total amount of power being applied through the electric arc controls. Silicon controlled rectifier (SCR) controllers are one type of control used in such furnaces, because an SCR is a solid-state switching device that can provide fast, highly variable, proportional control of electric power.

The challenge with SCR-controlled power using the phase-angle fired technique is that the voltage output is only close to a sine wave at high percentages of power output. At lower percentages of power output, a large amount of high-frequency noise is caused by the AC wave shape. These waveforms can be challenging for traditional transmitters to read, it is important to choose a power monitoring device that is highly accurate in this application.

This article briefly describes the process used for making glass in such a furnace, and one application that uses a Rockwell Automation control system with the addition of a Spectrum Controls power monitor module that evaluates and measures voltage and current signals from the power input to the furnace.

## Energy Produced by Electric Arc Furnaces

Electric Arc Furnaces (EAFs) commonly are used in making silica or quartz glass. Glass is produced by melting raw materials that include raw silica (silicon dioxide), soda ash, limestone and chemical compounds added to reduce the temperature at which the silica melts, and to alter the properties of the glass being manufactured.

Overall controls for an EAF typically include raw material infeed and processed material outfeed motors, plus sensors such as pyrometers. These controls usually include a servo-driven positioning system. Depending on the size of the furnace, the positioning system might be composed of electric motors with ball screws or a hydraulic servo system.

These furnaces use large amounts of electricity. The energy used to melt the glass accounts for about 75% of the total energy used during the glass making process.

The silica typically is melted using inserted electrodes with electricity flowing between them. Process control often is achieved via phase angle fired SCRs. Resulting waveforms are complex, making it difficult for traditional instruments to accurately measure RMS power output from the resulting current/voltage combination.

It's vital to maintain a balance between applying enough power to achieve the necessary temperatures for proper glass production and not overdriving the electrodes. Highly precise control of the power being applied is required to efficiently fire the electrodes to properly follow the control algorithm.

Closely monitoring the amount of energy being delivered through the electrodes is critical, because allowing excessive energy to be expended at a given electrode will eventually destroy it. Electrodes typically are made of metals such as platinum or molybdenum. Molybdenum is much cheaper than platinum. However, platinum has some special features that make it the choice for applications where the glass flow rate is crucial to the success of the forming or processing operation.

## Glass Manufacturing Requirements

This is the case when manufacturing tempered glass for applications such as windshields and cell phone face plates, where the glass is very thin. This type of glass manufacturing typically uses molybdenum electrodes coated with platinum, which has a melting point of 3,216°F (1,769°C). However, platinum or platinum-coated electrodes are only suitable for applications with temperatures up to about 2,642°F (1,450°C), because the metal tends to soften at the high temperatures needed to melt silica in the furnace.

This softening leads to a higher rate of electrode destruction, and to contamination of the glass with platinum or molybdenum. Alloys of platinum using zircon or gold are more

stable at these higher temperatures, making them more stable in the glass-making process.

However, for some kinds of glass manufacture, pure platinum, or platinum-coated electrodes, are the only suitable choice. These electrodes are expensive. Therefore, any reduction in the rate at which the platinum or platinum-coated electrodes are destroyed during the glass-making process is of value. Because platinum melts at a lower temperature than silica, additional chemicals are added to the silica to reduce the melting temperature of the compounds.

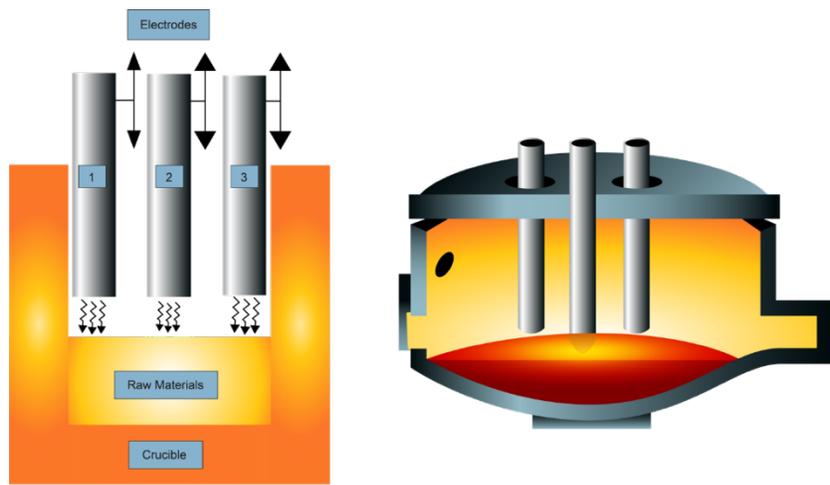
An EAF uses one to multiple electrodes to form the electric arc. The amount of electric power used depends on the voltage level and current flow. The electric arc appears when the electrodes are at the proper distance apart to allow arcing between the electrodes. You want to keep the electrode plates just close enough to allow the current to arc between them, but far enough away that the heat produced by the arcing doesn't overheat the plates themselves.

The most efficient method for verifying that just enough electrical current is applied to the electrodes to produce an arc that melts the silica — while at the same time keeping the temperature of the electrode metal low enough to reduce electrode destruction — is to use a control algorithm to control the electrode positioning system along with the EAF's SCR controllers. The algorithm should be able to compute an appropriate control action, along with optimizing the reduction of the tracking error by calculating the difference between the instantaneous output and set point.

The current draw needed to produce an arc between the two platinum-coated electrode plates is initially very high (see **Figure 1**). The control system has to be programmed to adjust the electrode spacing and control the SCR firing enough so that heat generation is brought to normal limits as soon as possible.

### Model of 3-Phase Electric Arc Furnace

**Figure 1:** *The current draw needed to produce an arc between the two platinum-coated electrode plates is initially very high. The control system has to be programmed to adjust the electrode spacing and control the SCR firing enough so that heat generation is brought to normal limits as soon as possible.*

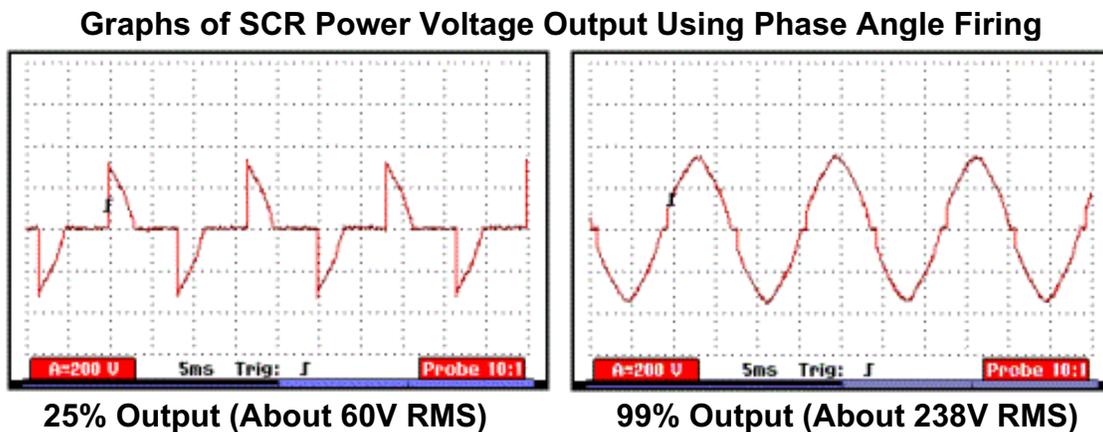


## Real-World Application

Let's examine an industrial system application already in use that solves a real customer issue. It uses a highly efficient glass EAF. Current flow between two platinum-coated electrodes is controlled by SCR controllers — a solid-state switching device that provides fast, variable, proportional control of electric power.

As mentioned previously, a challenge with SCR-controlled power using the phase-angle fired technique is that the voltage output is only close to a sine wave at high percentages of power output (see **Figure 2**). At lower percentages, a large amount of high-frequency noise is caused by the AC wave shape. It can be challenging for traditional transmitters reading the signal from a current transformer. It is critical to employ a power monitoring device that can be highly accurate under these conditions.

**Figure 2:** A challenge with SCR-controlled power using the phase-angle fired technique is that the voltage output is only close to a sine wave at high percentages of power output. At lower percentages, a large amount of high-frequency noise is caused by the AC wave shape.

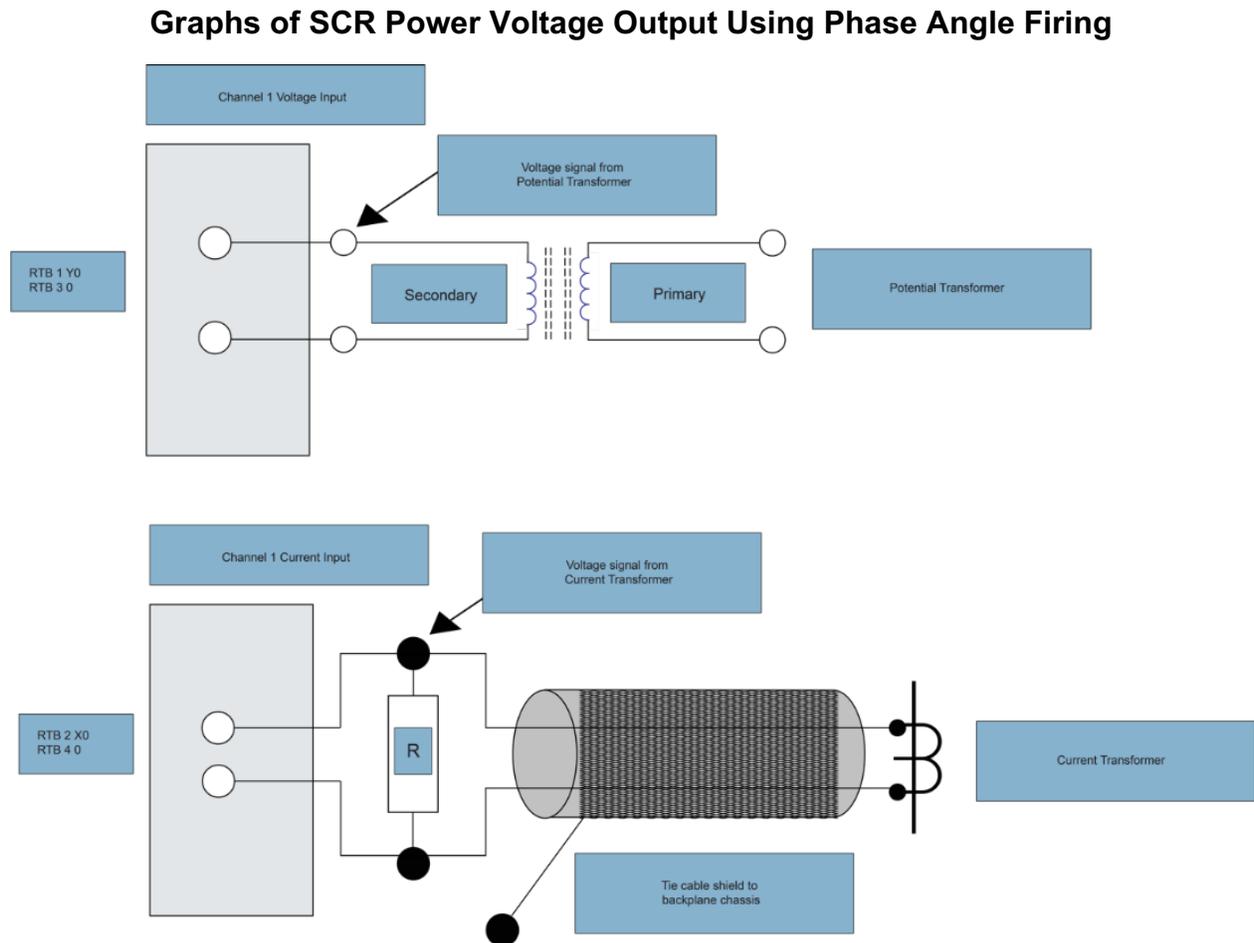


In this application, the glass furnace contains glass that has already melted. For the intended purpose of the final product, the molten glass must pass through a highly regulated series of heating and cooling to achieve the necessary characteristics needed for its specialty applications. Electrodes are inserted into the molten glass and energized to produce a heating source. As noted above, for a given glass recipe, a strict temperature profile of heating and cooling for the glass must be followed for the material to allow final shaping, finishing and annealing to occur.

To measure and control the amount of power being applied in the process, a Spectrum Controls power monitor module within an Allen-Bradley® ControlLogix® programmable automation controller (PAC) system from Rockwell Automation is a critical element within the closed control loop to precisely monitor the total amount of energy being applied to the glass at any given time.

Within the control loop, the ControlLogix controller uses information provided by the Spectrum Controls power monitor module to respond in real time to the material temperature to confirm that it's adhering to the predetermined temperature profile. The module can rapidly extract the RMS value of the power, even though the signal is highly distorted at lower power percentages, and to provide this information to the control system. The electrical wiring layout used for this system is outlined in **Figure 3**.

**Figure 3:** This electrical wiring layout was used for a glass manufacturing application in which a power monitor was used within the control infrastructure to measure and control the amount of power being applied when using electrodes in the process.



Because molten glass becomes fully conductive at a sufficiently high temperature, the electrical current flowing to the electrodes is continuous. With the power monitor module as part of the closed loop, the system is now able to manage the inherently unstable waveforms produced as a result of the current flowing between the electrodes. The module provides 8 pairs of current/voltage inputs and generates power measurements for each input pair at a 60-Hz update rate.

This implementation solved the problem of controlling the unstable waveforms and reduced the rate at which the electrodes are destroyed. Three benefits were realized from extending the life of the electrodes:

1. Extending electrode life reduces the contamination of the glass with the waste platinum.
2. With the high cost of platinum, any increased life expectancy for the electrodes can be a significant operational cost benefit.
3. Longer production cycles because of less maintenance.



*Spectrum Controls Inc., based in Bellevue, Washington is a participating Global Encompass™ Product Partner in the Rockwell Automation PartnerNetwork™ program. Spectrum Controls builds Allen-Bradley-compatible I/O modules, HART modules, industrial gateway's, PowerFlex® cards and industrial displays.*