Ceramic Kiln Temperature Testing
using the Personal Daq

Kiln-fired ceramic and glass objects require that a uniform temperature be maintained throughout the furnace to prevent the products from forming cracks and areas of high stress concentrations. These high-temperature kilns typically operate around 2000˚F during normal firing but can lose some heat through the lid and a few areas around the walls. Although the firebrick usually used for the furnace lining has relatively high heat storage capacity, it's not enough to compensate for conduction losses and non-uniform temperature distribution when the heater elements are cycled on and off. One way to compensate for thermal gradients is to customize the output power of several individual electric heating elements placed around the perimeter of the kiln. In specific areas that are shown to have a lower temperature, the nearest element can be adjusted to provide additional heat, but locating and measuring these thermal gradients in the furnace are not easy or simple tasks.

Variations in temperature distribution within the kiln are measured with several thermocouples strategically located to establish which of several heaters need to be adjusted for higher output. The thermocouples feed individual signal conditioner modules, which in turn connect to the Personal Daq for processing. The computer and Personal DaqView graphical data acquisition and display software provide permanent records and a hard-copy printout of the temperature profile for customers.

Potential Solution

A major U.S. based kiln manufacturer is particularly familiar with this technique. It has been producing ceramic and glass kilns for more than 56 years for hobbyists as well as the industrial sector. It began making measurements with a well-known brand of data logging card in a PC Jr. personal computer. Unfortunately, it could measure only five zones, an insufficient number of channels for one test to establish a temperature profile of the kiln space. Also, it required extensive programming, the data were not easy to display, and the time the card allowed for measurements was limited.
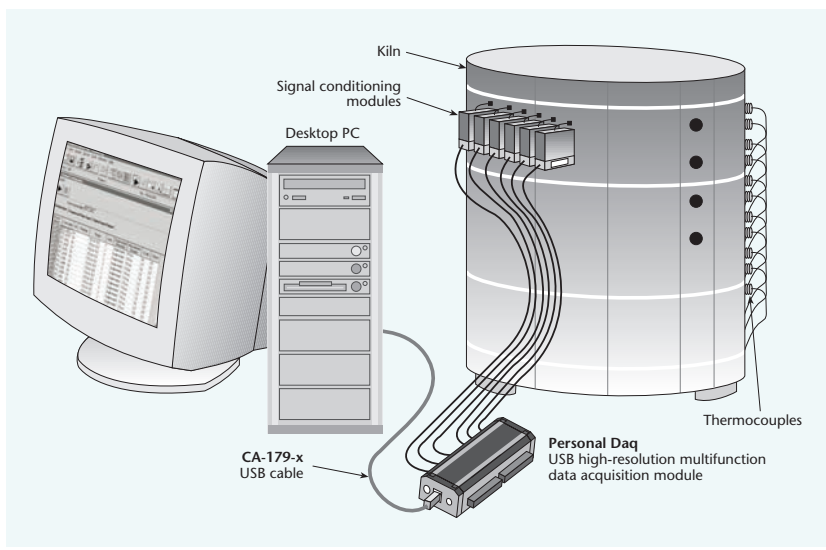
IOtech's Solution

The Director of New Product Development needed to record at least 10 channels simultaneously to obtain an accurate kiln temperature profile or a map of temperature gradients. Since he custom designs the heaters, he adjusts the wattage rating or heat output of individual heaters in those zones where the temperature may need to be a little higher or lower.

In order to find the measurement equipment to do the job, he evaluated several different types of data acquisition systems and selected an IOtech Personal Daq. The analog I/O section provides him with the 10 channels he needs, and the unit is much easier to set up than the system in the PC Jr.

The internal controller for the kiln uses type K thermocouples for most applications, and type S for higher temperatures. Exposed thermocouple junctions are located near the center of the kiln and their lead wires are supported by ceramic insulators. No protective sheath or other type of covering is used over the junction that might affect its speed of response to temperature changes. And because the junction is exposed to an aggressive and corrosive environment, the thermocouple wire is made of an unusually large gage of wire in order to sustain from 40 to 100 firings.

The company uses the Personal Daq to develop control programs for running both manual and automatic temperature vs. time profiles for prototype kilns as well as troubleshoot customer-returned controllers. The manual control program simply measures a set

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point temperature and cycles the heater elements on and off to maintain a single kiln temperature within 10°F. The automatic mode comprises six to seven temperatures and ranges, and eight different heating and cooling rates, programmable through a membrane touch pad and a four-digit LED display. The Personal Daq verifies the programmable temperature profile by making certain that all heating elements in their respective zones have been properly balanced.

Kilns and controllers returned for repair are also run through a temperature profile test using the Personal Daq to ensure that they meet original product specifications. "The eight to ten thermocouple zones connected to the Personal Daq can determine if any one or more of the heaters have open or shorted elements," says the Director of New Product Development. "In many cases, however, we find that the kiln is working to specifications." Here, the problem is a function of the raw material to be fired, such as its moisture content or composition, which the customer formulated for the kiln, not the kiln itself.

The Director of New Product Development finds the Personal Daq's USB port particularly convenient and effective. He also learned how to use the included software in about two days. "We don't need a lot of different setups," he says, "so once we establish the setup that works best for us, we just keep logging the data." In addition to logging temperature profiles, he installed a current sensor on the proportional SCR controller, connected it to the Personal Daq, and measured the percent of power the kiln used at different temperature ranges. "Usually between 1800 and 1900°F, the kilns run 100% of the time and could lose control of the heating rate," he says. "But before it can do that, the controller's microprocessor automatically kicks in, calculates the heating rate, and adjusts the shut-off temperature accordingly." Ceramics are time and temperature dependent, so for example, the kiln can run a load at 1400°F for two hours, or 1600°F for six hours to obtain the same results. All the while, the Personal Daq records the data, which helps him immensely in his design work.

One problem the company faced and was able to solve effectively was inductive pickup of the 60 Hz line voltage on the thermocouple leads. It is common to experience such interference when using unshielded thermocouples and leads in the presence of high currents such as those needed for the heating elements. The voltage exceeded 10 VAC when the kiln reached 1600°F, which affected the thermocouple readings and the Personal Daq performance. However, the problem was resolved by inserting a 60-Hz hardware filter in series with the thermocouple leads before they entered the Personal Daq.

Conclusion

The Director of New Product Development for a leading U.S. kiln manufacturer, uses a Personal Daq for measuring internal kiln temperatures to ensure uniform heat distribution. It provides new product design engineers with the data they need to adjust the output of heating elements placed in certain zones to make up for unavoidable, localized heat loss. They also use the Personal Daq to measure temperature profiles in customer-returned units in order to repair them or show the customer that the problem is with their raw glass or pottery materials, not the kiln. Customers receive a graph of the temperature vs. time profile to show that the kiln is within specifications, whether it needed repair or not.

Personal Daq/50 Series

Designed for high accuracy and resolution, the 22-bit Personal Daq data acquisition systems directly measure multiple channels of voltage, thermocouples, pulse, frequency, and digital I/O. A single cable to the PC provides high-speed communication *and* power to the Personal Daq. The Personal Daq modules are a family of low-cost, USB-based products from IOtech. Because of the strict power limitations of the USB, the modules incorporate special power-management circuitry to ensure adherence to USB specifications.

Features

- Multifunction data acquisition modules attach to PCs via Universal Serial Bus (USB 1.1 & 2.0 compatible)
- Ultra low-power design requires no external power or batteries
- Can be located up to 5 meters (16.4 feet) from the PC
- High-resolution, 22-bit A/D converter offers reading rates from 1 to 80 Hz
- Built-in cold-junction compensation for direct thermocouple measurements
- Frequency/pulse, or duty-cycle measurements up to 1 MHz
- Convenient removable screw-terminal signal connections
- 500V optical isolation from PC for safe and noise-free measurements
- Programmable inputs from ±31 mV to ±20V full scale
- Digital I/O lines with open collector output for direct drive applications
- Expandable up to 80 channels of analog and digital I/O
- Up to 100 Personal Daq modules can be attached to one PC using USB hubs, for a total capacity of 8,000 channels
- Digital calibration — no potentiometers or adjustments required

Software

- Personal DaqView *Out-of-the-Box* spreadsheet-style software for setup, acquisition, and real-time display
- PostView included for post-acquisition data viewing
- Support for Visual Basic®, C/C++, DASYLab®, and LabVIEW®

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