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# Application Note: Exactus® Temperature Measurements for Improved Fiberglass Bushing Control.

**Process Challenges:** One of the long-standing challenges of structural fiberglass manufacturing has been achieving a stable and reproducible bushing temperature. Due to variation in location and attachment welding of the control thermocouples, the operating set point temperature of new bushing assemblies can vary widely. As the bushing ages, the control thermocouples will also drift requiring frequent adjustments to the process set point over time. These two factors combine such that any two bushings in a process line are rarely operating at the same temperature. Figure 1 below shows the temperature drift that can occur in the control thermocouple measurement over the life of the bushing.

**Typical Bushing Thermocouple Drift Over Life of Fiberglass Bushing**

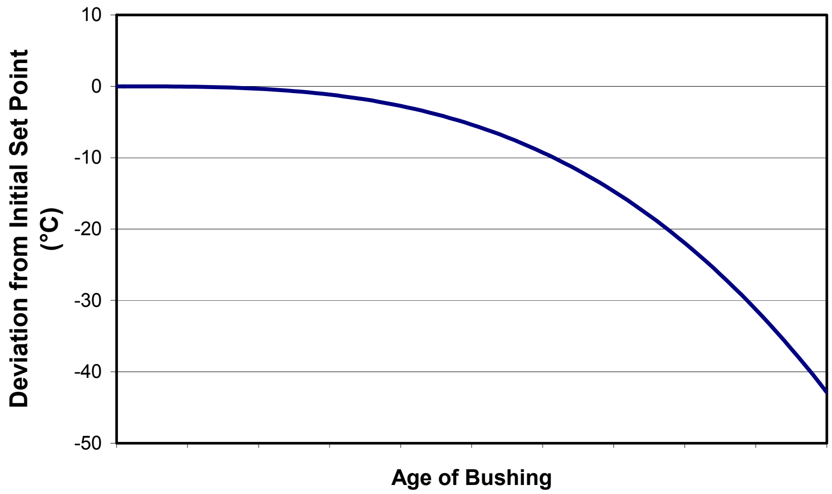


***Figure 1:*** *Drift of thermocouple measurements over time.*

An additional problem is the stability of the process control, even over the short term. Eliminating measurement noise in a thermocouple is always difficult. This problem is increased when the bushing assembly to which the thermocouple is attached, is resistively heated with a direct high amperage electric current. Poor stability and noise in the control measurement will transfer directly to the bushing control. Figure 2 shows data from an optical temperature measurement of a bushing sidewall and the variation that can occur at both low and high frequencies.

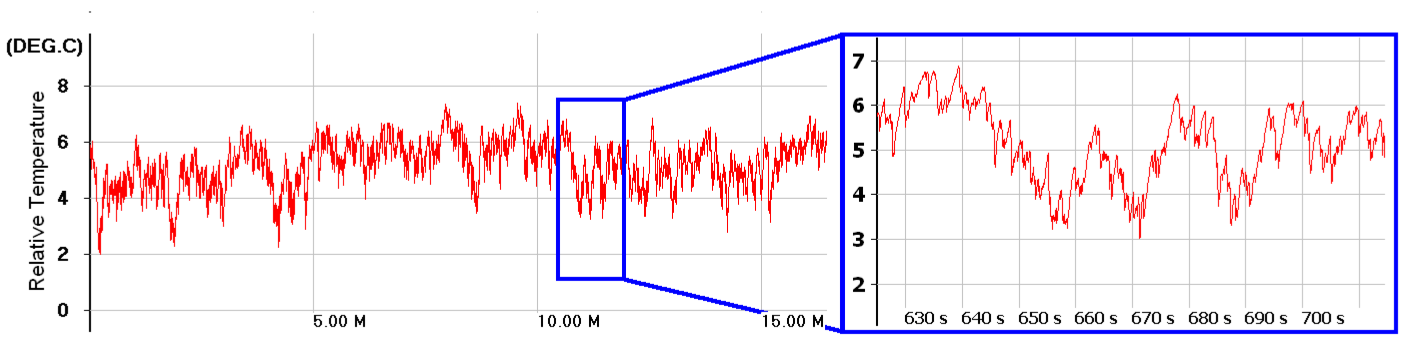


***Figure 2:*** *External Bushing Temperature Measurement over 16 minutes.*


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Improving the temperature stability of a structural fiberglass bushing assembly can increase production efficiency, improve fiber diameter tolerances, and reduce quality control costs. Reducing the measurement drift can eliminate many of the frequent manual adjustments required for proper process control. To address these problems, BASF Corporation has introduced its proven Exactus® optical temperature measurement solution in this application to provide stable, reliable and repeatable bushing process temperatures.

***Exactus optical temperature instruments, with negligible drift, fast update rate, and better than 0.01°C measurement resolution enable dramatic improvements in bushing temperature measurement and control.***

**Past Attempts:**

Initially explored many years ago, a high-resolution optical fiber sensor measured molten glass temperature in the bushing using a sapphire light pipe inserted into the bushing wall. This instrument improved the resolution of the temperature measurements provided to the process control system. The higher resolution optical measurement led to better initial and short term temperature stability which improved the uniformity of the drawn fiber over a two month test.

The light pipe method demonstrated the potential of an optical measurement but over time revealed a significant drawback as the measured temperature gradually declined. The platinum out-gassed and re-deposited onto the slightly cooler sapphire, influencing the measurement. Simply eliminating the light pipe and measuring the surface of the bushing also proved unreliable due to uncertainties with surface emissivity and environmental conditions.

**New Approach:**

BASF's precision optics can measure a small platinum target in the sidewall of the bushing from a short distance away to overcome these issues (see Figure 3). The target temperature is driven by the temperature of the glass just above the bushing tips; this minimizes the impact of environmental conditions on the measurement. Radiation from both the bottom and sidewalls of the target cavity reflect multiple times before exiting the cavity, each reflection raises the emissivity. This results in a temperature measurement unaffected by variations in the specific surface emissivity.

Effectively immune to emissivity changes and using the sophisticated electronics of the Exactus® pyrometer which drift less than 0.1°C per year, the bushing temperature will no longer drift with time.

The platinum target is simple and straightforward to incorporate in the bushing. The target diameter in the wall and through the frame and refractory need only be large enough for the instrument to maintain a reliable view of the target. For an optic mounted within 300mm (~12 inches), the image measured is under 2mm in diameter. Allowing for thermal expansion, a mounting hole as small as 4mm is reasonable. A platinum target with a 4mm diameter viewport needs to protrude only 12mm into the bushing.

A laser illuminator and an adjustable mount facilitate easy alignment of the lens with the target. Depending on the environment, housings may incorporate a low flow of purge air to insure the lens assembly remains clean and dry.

The first implementations of this system in Europe and North America are underway. The Exactus output is being used for bushing control and to monitor thermocouple control. The initial results are encouraging. Significant thermocouple drift has already been seen in contrast to generally stable optical measurements. Successful implementation will enable increased production efficiency, improved fiber diameter tolerances, and reduced quality control costs.

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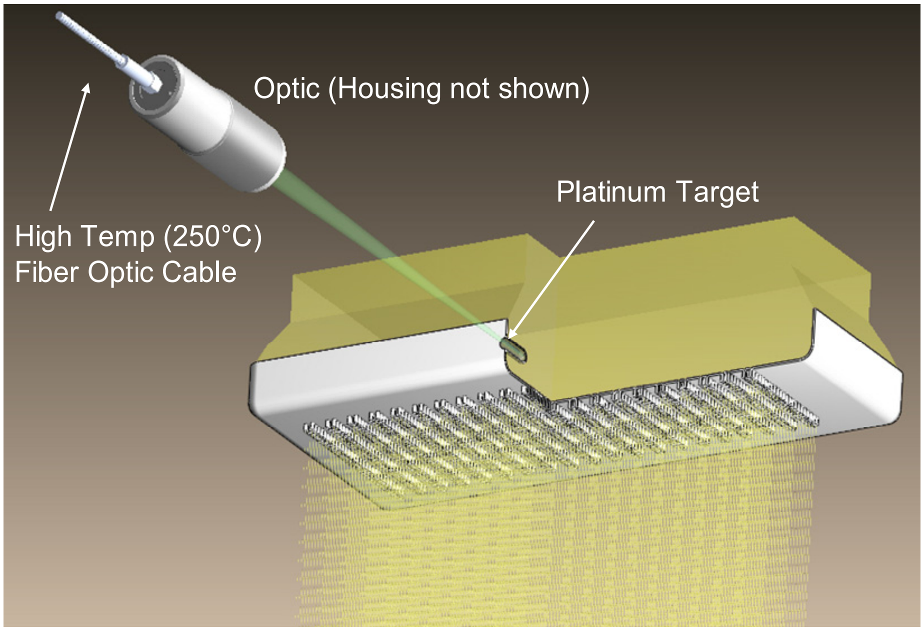


***Figure 3:*** *Fiberglass bushing with optical temperature measurement of a small target embedded in bushing wall.*

Measurements between bushing positions can now be reliably compared regardless of how long the bushing has been in process. Reliable initial process set points, that do not require manual adjustment, become possible. Tighter control using the better than 0.01°C resolution output at trusted process temperatures can improve bushing production efficiency and fiber diameter tolerance. With increased confidence in process performance and reliable measurements for control, significant reductions in quality control costs are possible.

**How stable can the process be?** Process stability depends a great deal on what is being controlled, the type of heating, and the hardware involved. Exactus instruments are used in the measurement and control of a particular type blackbody calibration furnace used by several national calibration laboratories. The cavity for this furnace is made of a large diameter graphite tube heated by a high amperage electric current, very similar to how a fiberglass bushing is heated. Figure 4 shows the level of process stability possible when a high resolution optical measurement is used for the control of this type process. The data shown is from a secondary monitoring sensor, not the control sensor.

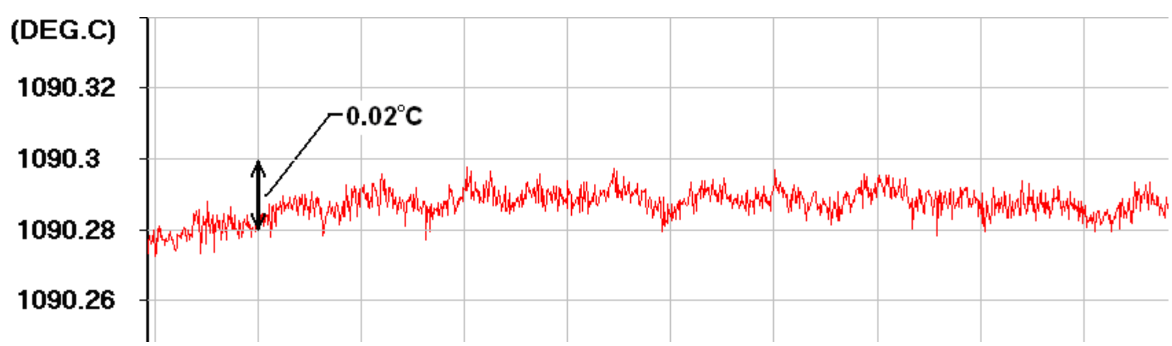


***Figure 4:*** *Closed-loop control of a resistively heated graphite furnace.*

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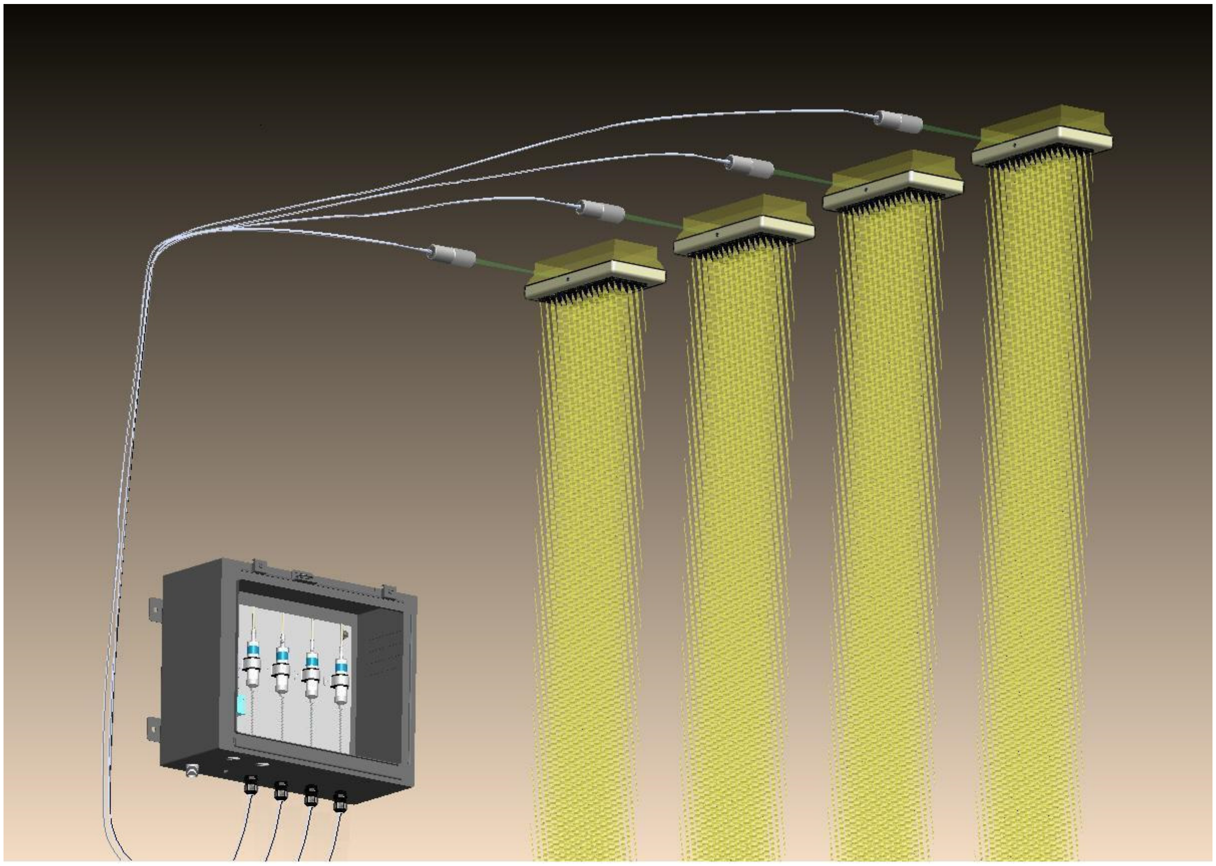

***Figure 5:*** *Multichannel cabinet providing measurement for four bushing assemblies.  Larger and smaller cabinets available.*

**Cost Effective Implementation:** The small size and multiplexing capability of the Exactus instrument and support hardware allow for cost effective process improvement across the entire production line.

By combining our process measurement experience with the unique attributes of the Exactus industrial measurement systems, BASF has developed a measurement solution for the structural fiberglass industry that increases uptime and reduces process variation, both within individual bushings and across groups of bushings.


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