TYPE N THERMOCOUPLE VERSUS TYPE K THERMOCOUPLE IN A BRICK MANUFACTURING FACILITY

The following paper was presented by Barbara Hudson, former General Manager of JMS Southeast, Inc., at the Brick Plant Forum Convention at Clemson University in Clemson, South Carolina.

ABSTRACT:

The brick industry historically has had the option of a Type K thermocouple, which is inaccurate yet inexpensive, versus Type R and S thermocouples which are very expensive yet accurate. This article investigates the Type N thermocouple which has been developed as a substitute for the Type K thermocouple in the 32°F to 2300°F temperature range.

TYPE K VERSUS TYPE R OR S THERMOCOUPLE

Through the years, many changes have occurred in the firing of structural clays including gas, oil, and sawdust combustion. Yet, the temperature measuring methods has remained the same as far as thermocouple configurations are concerned. Throughout history, a Type K thermocouple has been used in an area which was thought of as being "non-critical". The Type R or S thermocouples (platinum-rhodium) have been used in the past in "control" areas. The reasons for these uses include: Type K thermocouples, but are also less stable and less accurate. Type K thermocouples are easily attainable, however, and widely accepted in all industries.

The reasons for the instability in Type K thermocouples are due to some inherent properties in the chromel/alumel material. One problem that occurs with this thermocouple is an effect called short-range ordering. It occurs in a temperature range of about 500°F to 1020°F when nickel and chromium atoms in the chromel leg tend to form an ordered crystalline structure. The ordering produces a different metallurgical structure and if a temperature gradient exists, an erroneous EMF is produced.

Another shortcoming of Type K thermocouples is the hysteresis effect that occurs when a Type K thermocouple is cycled up and down in temperatures above and below 1800°F. The re-ordering of the crystalline structure changes with each cycle. After the first pass above this temperature, the Type K temperature indication will probably be accurate. However, with each additional cycle after this one, the error will increase more and more. The Type K thermocouple also experiences a cumulative drift after a period of time at temperatures above 1650°F. Finally, this thermocouple experiences a physical defect called "green rot" which is caused due to preferential oxidation of the chromel leg.

Even with these problems of instability and lack of longevity in Type K thermocouples, they are widely used and accepted in the brick industry as well as other industries. This is due to the fact that they are inexpensive and the choices have been limited in the past to a thermocouple that could replace Type K at a comparable price.

The platinum-rhodium thermocouples (Type R and S) on the other hand have been used as control thermocouples in the past. They are much more stable than the Type K thermocouples, but much more expensive also. They can be ten times the expense of a Type K thermocouple. Type R or S thermocouples do, however, after a period of time at elevated temperatures, experience a drift due to platinum migration.

In essence, for temperature measurement in a brick kiln, we have a fairly accurate option at a high cost versus an unstable and "short life" option at a reasonable cost. A compromise was needed!

TYPE N THERMOCOUPLES

Noel Burley, from Australia, began extensive research on a type N thermocouple (nisil/nicrosil). The composition of this thermocouple is the following: Nicrosil-NI-14.2%, Cr-1.4%, Si and Nisil-Ni-4.4%, Si-.1%, Mg. Noel Burley's research showed that the Type N thermocouple exhibited thermal stability above 1650°F, while Type K thermocouples showed a gradual and cumulative drift. He also showed the Type N thermocouple showed no short-term change due to crystal restructuring that occurred with the Type K thermocouple. Also, the Type N had superior resistance to oxidation (no "green rot") and could replace the Type K throughout its entire range of 32°F-2300°F. Its cost is about the cost of a Type J thermocouple. Due to this information, we decided to experiment with the Type N thermocouple in a brick manufacturing environment.

EXPERIMENTATION:

Frank Todd and Frank Todd, Jr., at Fletcher Brick were kind enough to allow us to do some experimentation in their facility. We were restricted to a short time frame, so we needed accelerated life data on comparisons between a Type K and Type N thermocouple. In communication with Fletcher Brick, a top to bottom and side to side temperature gradient was suspected in their tunnel kiln. They desired better monitoring to attain better control, thus better brick. If they were to go to platinum/rhodium thermocouples as side port monitoring sensors, the thermocouples alone would have cost in excess of $6,000 not including the data logger needed for data collection. Due to accelerated life data needed, we used 20 gauge thermocouples realizing they would deteriorate quickly. Stage 1 of our experimentation included manufacturing 10 dual thermocouples which consisted of one 20 gauge Type K and one 20 gauge Type N thermocouple in each sensor. These were installed in side ports of the kiln and ran for 30 days. The Type R thermocouples existed in the top center of the kiln as control thermocouples. All monitoring thermocouples were connected to a 40 channel data logger which printed the temperature of all sensors every six hours. This data was converted to actual temperatures for the Type N thermocouples and was compared to the control Type R sensors for kiln changes. After all the data was compiled, the drift was plotted for four Type K thermocouples. The drift of the Type K thermocouple was difficult to predict. All four sensors drifted in non-repeatable and inconsistent patterns.

The Type N readings were graphed and they also failed within the 30 day period as was predicted since 20 gauge wire was used. The drift, however, was more predictable. This was only a preliminary stage of our experimentation. We will continue our work with the 14 gauge Type N versus Type K thermocouples.

CONCLUSION:

In conclusion, Type N thermocouples can be used in all areas of the brick; i.e. traveling thermocouples, air conditioning vents, kiln control, monitoring sensors, and drying sensors.

Research has shown Type N thermocouples have better thermal stability than Type K in the temperature range of 1200°F-1400°F, which is the pre-heat zone where carbon burn-out occurs.

Also better control can be obtained with a Type N thermocouple at the quartz inversion point of 1050°F.

Two or three different types of thermocouples used in a single plant within the Type N temperature range of 32°F-2300°F can be replaced by the Type N thermocouple. This would standardize the plant with one type of thermocouple enabling the use of one type of controller, one type of data logger, etc.

This thermocouple is also ASTM certified. It has been given a color code of orange/red. It is listed in most thermocouple manufacturers catalog. We at JMS Southeast, Inc., will continue doing research with the Type N thermocouple in structural clay firing applications.

REFERENCES:

1. Brick Association of North Carolina (Marion Cochran).
2. The Nicrosil versus Nisil Thermocouple: Properties and Thermoelectric reference Data - NBS Monograph 161.
3. Temperature Sensors Product Information Bulletin (TS-02) by R. Kampion of Leeds and Northrup.