Reconditioning Ceramic Insulators

Trevor Jones – Solar Atmospheres, Souderton, Pa.

Furnace insulators are designed to electrically and thermally insulate. When they become coated with metals and carbon from high-temperature processing, their electrical resistance is compromised. This article discusses a technique to restore the insulator to its original purpose.

A vacuum furnace's ceramic insulators, located on graphite heating elements, may become coated from metal vapors or other conducting material such as carbon from heat-treating processes. These coatings can cause the electrical resistance of the insulators to decrease dramatically and, in addition, have the potential to ground a heating element. As a result, heating will become unstable and non-uniform.

Solar Atmospheres has been researching this problem, and a study was performed to determine if the metal and/or carbon conducting substances could be on the ceramic insulators. The clean (reduction) procedure used a relatively low furnace temperature of 1250°F, with air at a pressure of 25 torr. Naturally, the removal of the conducting material was to be accomplished without causing any detrimental effects on the hot zone of the furnace.

Sample	Weight (grams)	Resistance (Ω)
A	7.46	16.66
B	8.27	17.66
C	5.65	9.76 k
D	5.34	20.33 k
E	5.79	3
F	5.97	1.33

Table 1. Weights and resistance prior to reduction test

Sample	Weight (grams)	Resistance (Ω)
A	-0.02	∞
B	0.02	∞
C	-0.02	∞
D	-0.05	∞
E	0.01	3.66 M
F	0.09	∞

Table 2. Weights and resistance post reduction test

Procedure

A total of six used ceramic pieces were retrieved from various vacuum furnaces where processes, including vacuum carburizing, had been performed. The ceramics were placed in a laboratory furnace that has a graphite hot zone. Photos of the ceramic pieces before (Fig. 1) and after (Fig. 2) testing are shown, in addition to photos of the hot zone before (Fig. 3) and after (Fig. 4) treatment.

The processing procedure involved placing the ceramic specimens on a stainless steel screen in the center of the furnace (Fig. 3). The furnace was then pumped down from atmospheric pressure to 25 torr. After pumping down, the furnace ramped at a rate of 20°F per minute to 1250°F with the air constantly being introduced and evacuated from the furnace with mechanical vacuum pumps maintaining a pressure of 25 torr. The specimens were photographed, weighed and the electrical resistance measured before and after the treatment. The furnace was held at 1250°F for two hours. Then the specimens were static cooled to room temperature at a pressure of 630 torr with nitrogen gas.

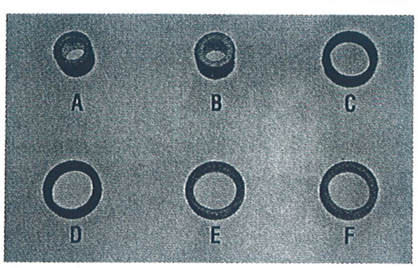

Fig. 1. Ceramics prior to reduction test

Results

The appearance of the ceramics before the run was a mixture of blue, gray and purple – all dark in color. After the cycle was completed, the darker hues disappeared on the ceramics, and a white surface emerged.

No hypothesis was made prior to the test on the cycle's effect on the ceramics' weight. There was virtually no weight gain or loss on all six of the ceramics. After the cycle, however, the appearance of lighter colors on the ceramics indicates a reduction has occurred and that the weight should be less. This may also imply that no dissolving or attacking of the ceramics had taken place during the test run.

The resistance of the ceramics increased to levels that insulators should possess. All of the insulators increased to virtually an open circuit with the exception of sample E. This ceramic increased to more than a high enough resistance – approximately 3.7 MΩ.

The appearance of the hot zone after the test indicated that a coating (probably an oxide) formed on the graphite thermal in-

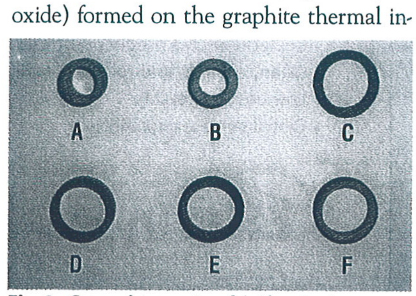

Fig. 2. Ceramics post reduction test

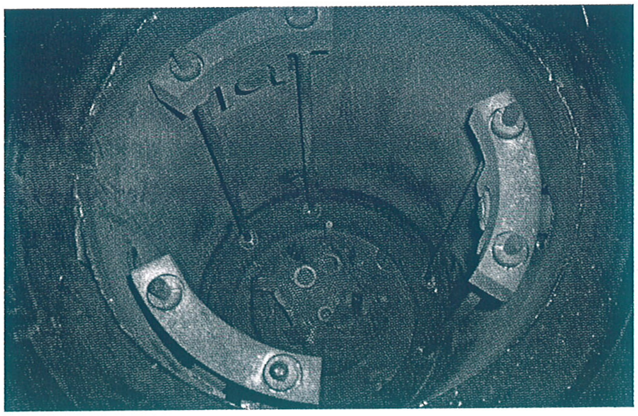

Fig. 3. Furnace post reduction test

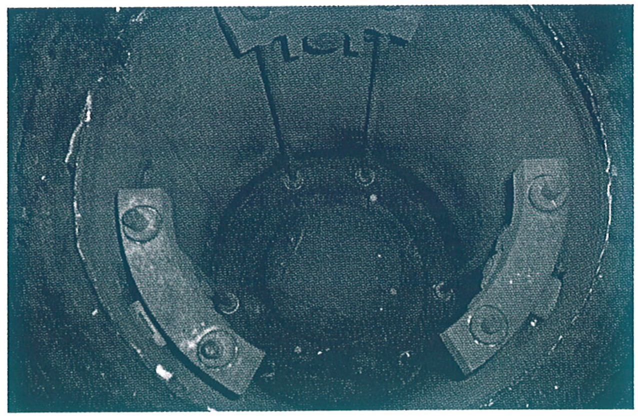

Fig. 4. Furnace post 1250°F bake out

sulation and heating elements. The colors were purple, blue, orange and yellow. Although these colors are not normally seen in graphite hot zones, the process did not seem to attack the insulation or degrade it in any way. These colors also could have been a result of the oxide vaporizing off the ceramics and collecting on the hot-zone face.

A cleanup cycle was performed after the ceramic test to determine if the hot zone would burn out the coating impurities that collected during the ceramic reduction test. The furnace was mechanically pumped down to less than 25 microns, heated to 1250°F and held for four hours.

No high vacuum or partial-pressure gases were used in the cleanup cycle, only the mechanical pump. The reason for using only the mechanical pump was the ceramic reduction test was performed on a low-temperature vacuum furnace (1250°F), and there were no possible high-vacuum or hydrogen capabilities that would assist in cleaning up the graphite hot zone. The hot zone did improve, but the effect was only marginal.

In a standard high-temperature, high-vacuum furnace, oxides formed on the graphite would completely dissolve after one burn-out, but the test parameters consisted of a lower-temperature furnace with no high-vacuum capabilities.

Conclusions

The ceramics were transformed successfully from conductors back to insulators for the required vacuum-furnace processing. Further testing at 1150°F or lower may determine how low a temperature is needed to successfully bake out the ceramics to restore the insulating characteristics. By doing so after the process, the ceramics could be removed from the furnace and then the hot zone could be baked out at 1250°F. Another option would be to leave the ceramics in place, without removal, for this cleanup process.

By going 100°F higher in temperature than the reduction test, the hot zone should clean up more effectively. **IH**

For more information: Trevor Jones is project engineer at Solar Atmospheres Inc., 1969 Clearview Road, Souderton, Pa. 18964; tel: 215-721-1502 Ext. 351; fax: 215-258-3657 e-mail: tmj@solaratm.com; web: www.solaratm.com

Additional related information may be found by searching for these (and other) key words/terms via BNP Media SEARCH at www.industrialheating.com: ceramic insulators, hot zone, vacuum carburizing, reduction