THERMAL AND ELECTRICAL PROPERTIES OF PETROLEUM COKES

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The overall coefficient of heat transfer of several fractions of sized petroleum coke particles was measured at different temperatures under a static pressure of 3.0 PSI. The temperature gradient across 2.5 cm of material was measured during a steady state thermal equilibrium condition. A radial-out-flow device, 9.5 cm ID by 12.0 cm OD, with an electrical resistance heat source was used, and the coefficient of thermal conductivity (k) of the samples was calculated from heat flow measurements using the log-mean temperature difference. Heat balance was maintained axially so that a radial heat flow could be approximated. The resulting calculations ignore convective and radiation losses through the granular matrix. However, for reasonably small temperature gradients at low sample temperatures the k-value provides a quick and quite realistic measurement of the conductive heat loss through a sized granular, insulation barrier. Comparison of these coefficient values between cokes with varying degrees of heat treatment and for different sizes of coke particles allows the proper choice of material for thermal insulation of graphite or other high temperatures furnaces.

The k-values of sized petroleum coke particles in Tyler screen size fractions of -10/20 mesh, -20/35 mesh and -35/60 mesh were studied on a normal calcined coke which was later graphitized to 2500°C. Figure #1 shows the k-values for the calcined coke for average temperatures from 100°C to 600°C. The k-values for the three particle size fractions were remarkably similar. The overall difference was less than 20%.

Figure #2 shows the k-values for the same size fractions after the coke was graphitized to 2500°C. The k-values for the graphitized coke were two to five times higher than for the calcined material. The k-value for any specific particle sizing generally increased from 20% to 50% as the average sample temperature increased from 100°C to 600°C. Since the thermal conductivity of graphite decreases with temperature the measured increase of k-value with temperature is due to the increased significance of convection and radiation modes of heat transfer. The particle sizing had a much greater effect on the k-value of the graphitized coke than the temperature. The similarity of k-values between the different sizes of calcined coke does not exist for the graphitized particles and coarser size fractions have higher k-values.

While the thermal conductivity of an insulation coke material is an important design parameter for high temperature work, the electrical resistivity (ER) is also important due to the current losses through the conductive coke medium when using electrical resistance heating as is currently practiced by manufacturers of carbon and graphite products particularly when processing electrodes in Acheson graphite furnaces. Since the thermal conductivity and ER of a particle matrix are a function of pressure and particle sizing as well as temperature, a study was made of the ER properties of both a calcined and graphitized petroleum coke for 5 closely sized particle fractions from -10/20 mesh to -200 mesh. These measurements were made on a cylindrical column of coke particles at room temperature under static pressure loads from 1 to 10 psi. These tests differ from traditional ER measurements on coke particles in that the particle sizing was coarser and the packing density was altered only by the small applied pressure. These ER values include both the particle resistivity and contact resistances between the particles and, therefore, provide a useful approximation to the actual operating resistance which would be encountered in a high temperature electrical furnace.

Figure #3 shows the change in ER with increasing pressure for both a calcined and graphitized petroleum coke sized to -10/20 mesh particles. The plots are shown as log-log graphs due to the exponential decrease in ER with increasing pressure caused by the rapid decrease in particle contact resistance. The difference in ER between the calcined and the graphitized material is one order of magnitude. This was an expected result since the graphite structure of the coke particles would substantially reduce the ER of the material.

Figure #4 shows the ER at a static pressure of 5 psi for petroleum coke in size fractions of -10/20 mesh, -20/35 mesh, -35/65 mesh, -100/200 mesh and -200 mesh for both calcined and graphitized particles. The horizontal scale is based on the log of the average particle diameter within each size fraction. For both the calcined and graphitized material, the ER of closely sized particle fractions increased as the average particle size decreased. This is due to the inverse relationship between particle size and the number of contact resistances per unit volume of material. Due to the changes, in ER for various particle sizings and heat treatment temperatures, any particular coke material could be tailored to fit a required ER value by judicious selection of particle sizings and degree of heat treatment. Combining these data with the previously discussed thermal conductivity data will allow the most profitable selection of coke for furnace packing.

References

1. McAdams, Heat Transmission, McGraw-Hill, 1942.

2. Pinnick, Proceedings of the 1st and 2nd Carbon Conferences, University of Buffalo, 1953.

COEFFICIENT OF THERMAL CONDUCTIVITY VS. AVERAGE TEMPERATURE

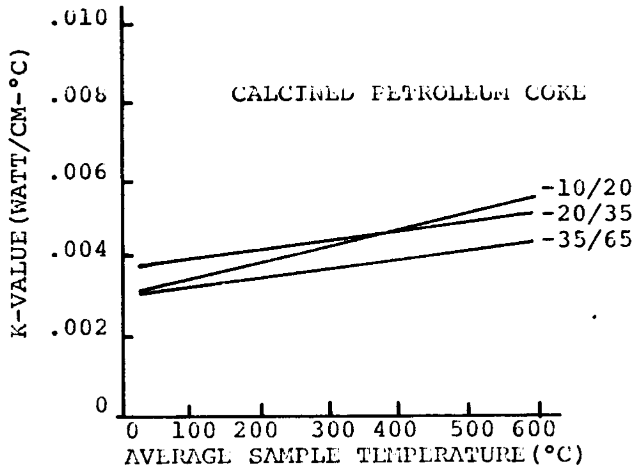

FIGURE 1

COEFFICIENT OF THERMAL CONDUCTIVITY VS. AVERAGE TEMPERATURE

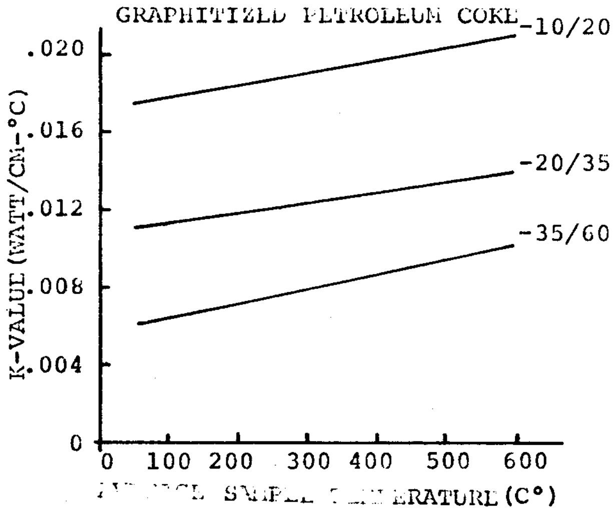

FIGURE 2

ELECTRICAL RESISTIVITY VS. APPLIED PRESSURE

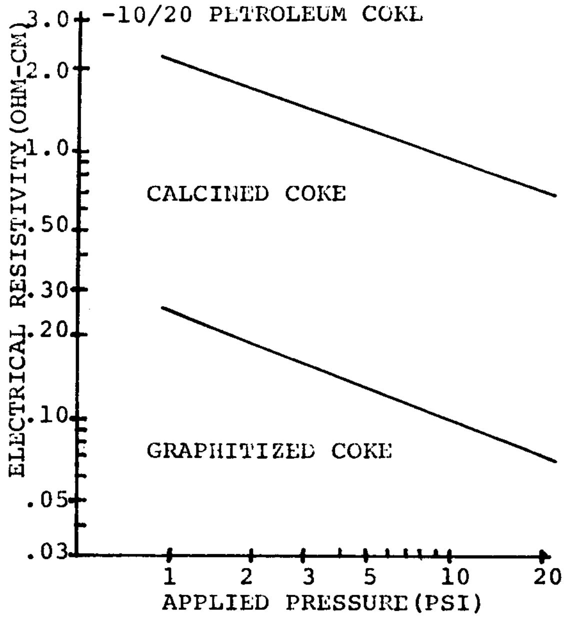

FIGURE 3

ELECTRICAL RESISTIVITY VS. PARTICLE SIZING

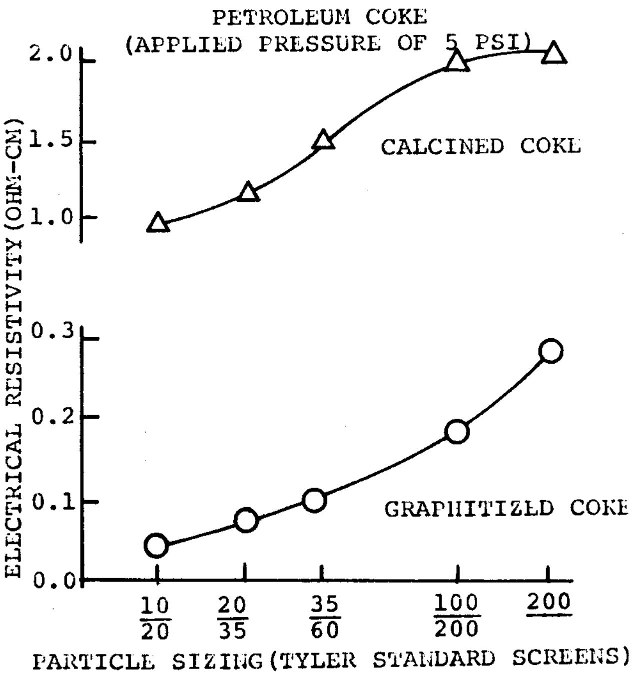

FIGURE 4