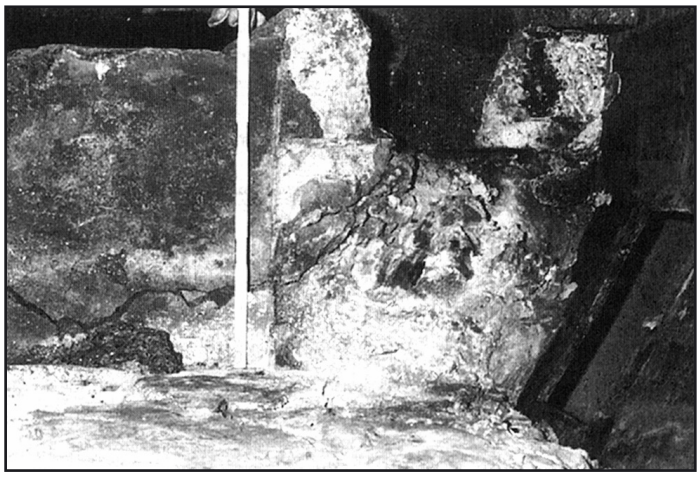
Thermal Expansion or Contraction

Introduction

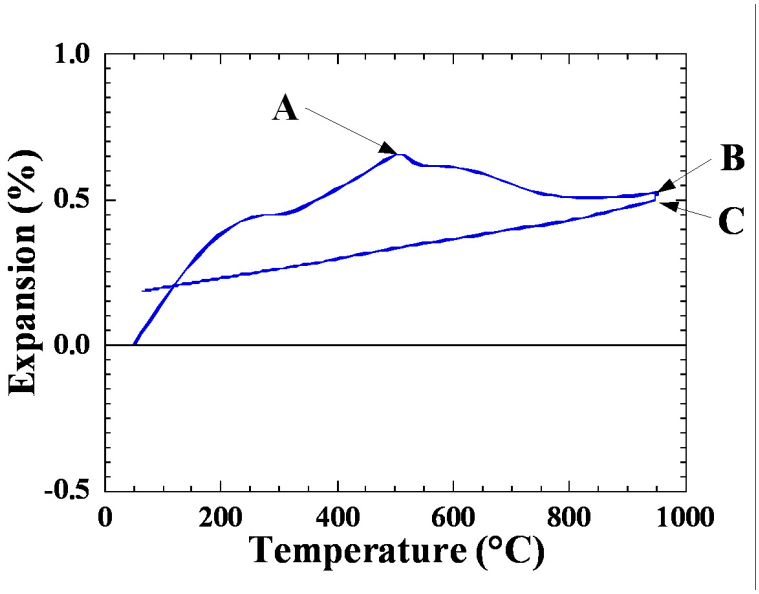


In the temperature range from 500 to 950 °C ramming paste will shrink due to carbonization and contraction of the binder. This shrinkage may be counteracted by proper granulometry and pitch content. If the shrinkage is too large >0.2%, the paste will crack and aluminium and bath will penetrate to the bottom of the cell. The picture shows aluminium penetration in a cell that was stopped after 5 days due to crack in the big seam.

Dilatometer Recordings

A typical dilatometer curve for a standard ramming paste may look like the curve below. A softening of the pitch will occur up to about 100 °C, including an expansion due to release of internal stresses. From 100 to 300 °C the viscosity of the pitch is reduced dramatically and an expansion due to release of captured gasses starts. A certain penetration of pitch into the coke will occur at these temperatures. Between 300 and 500 °C starts the release of hydrogen and volatile gasses. At about 500 °C the tar has carbonized to a solid coke. Synthetic binders of the phenolic resin type solidifies at around 300 °C and show a different dilatation curve. At higher temperatures the main off gas is hydrogen which is nearly completely removed at 1000 °C. The cooling curve shows the reversible linear thermal coefficient of expansion.

Thermal shrinkage is defined as the difference in expansion between point A and point C, i.e. the difference between the solidification expansion and the expansion after 3 hours at 960 °C. Values should be well below 0.2 % shrinkage and preferably below 0.1 %.



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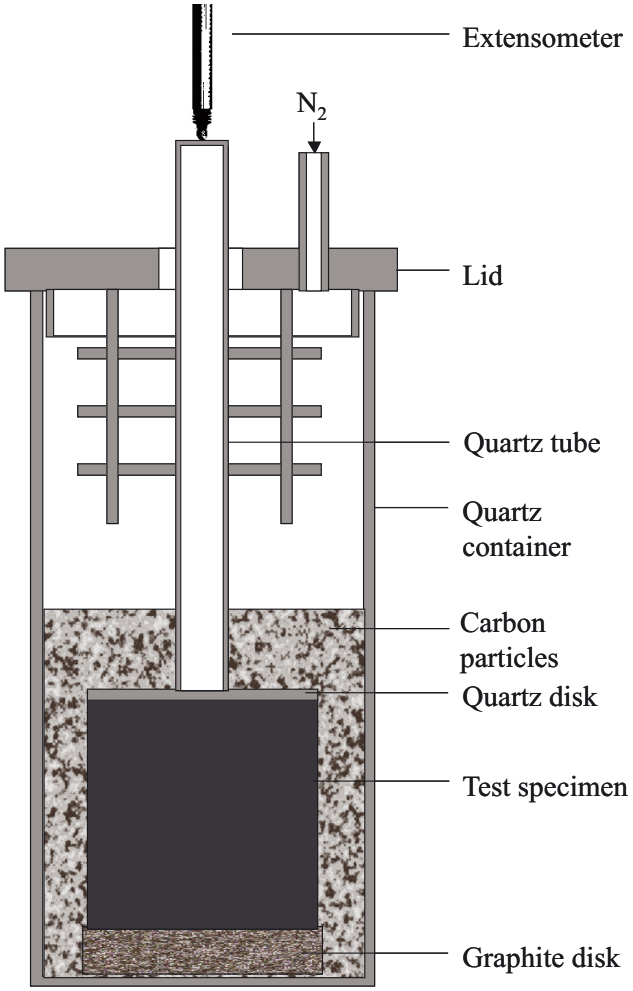
Experimental

A sketch of the dilatometer is shown below. Quartz is used in most parts due to its low thermal expansion. In addition, the movements of the quartz push rod is measured relative to the quartz reference tube. Dilatation is registered by a linear variable differential transducer. The measured dilatation and temperature is continously logged and stored in an Excel worksheet format.

The sample size is typically 50 mmØ x 50±5 mm. Normal heating rate is 3 °C/min and maximum temperature with existing equipment is 960 °C. The sample is kept at the maximum temperature for 3 hours before cooling.



Reference:

M. Sørlie and H.A. Øye, “Cathodes in Aluminium Electrolysis”, 2nd Edition, Aluminium-Verlag, Düsseldorf, 1994, p. 408.

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