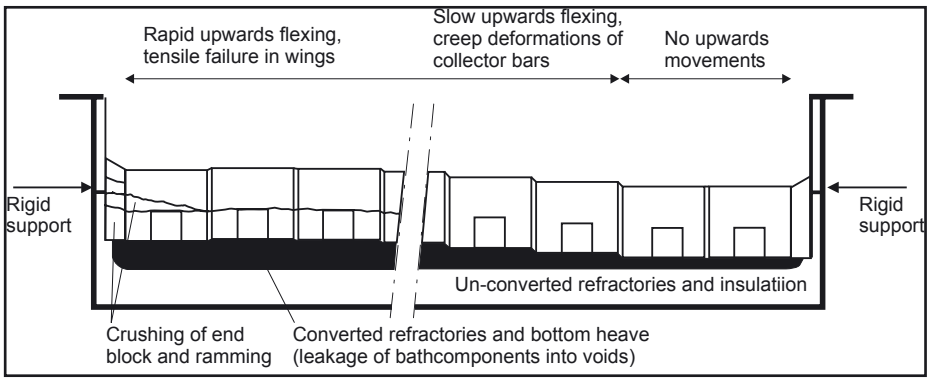
Expansion Due to Sodium Penetration
Rapoport Test with Pressure

Background and Relevance

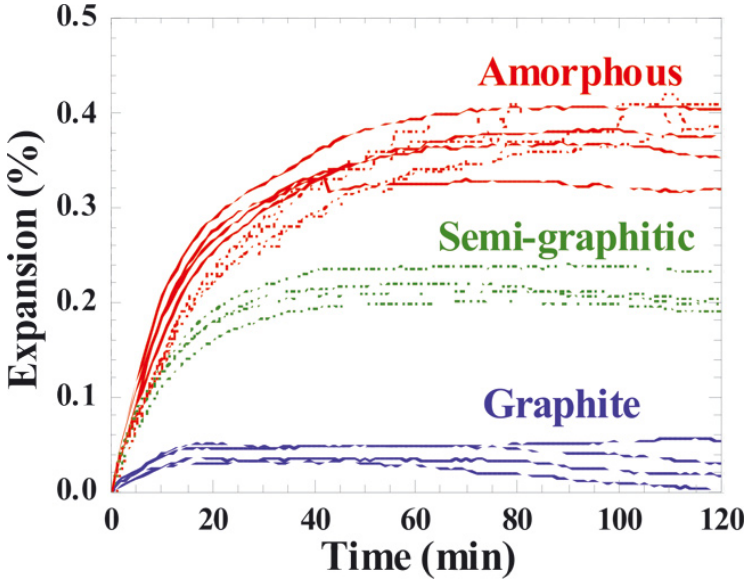


The resistance towards deterioration of cathode carbon materials used in aluminium cells following attack by sodium and electrolyte is one of the predominant parameters determining the cell life. As soon as electrolysis is started, sodium penetrates into the carbon cathode blocks causing swelling that creates mechanical stresses within the blocks. This may cause cracking and upheaval of the bottom blocks which may cause cell failure if metal or bath damages the refractories, or current conductors. Therefore, cathode blocks produced with materials allowing only slow sodium penetration and having low expansion due to sodium penetration are preferred.

Results

The Rapoport test with pressure determines linear expansion due to the sodium penetration. The method is presently under consideration as an international standard (ISO/WD).

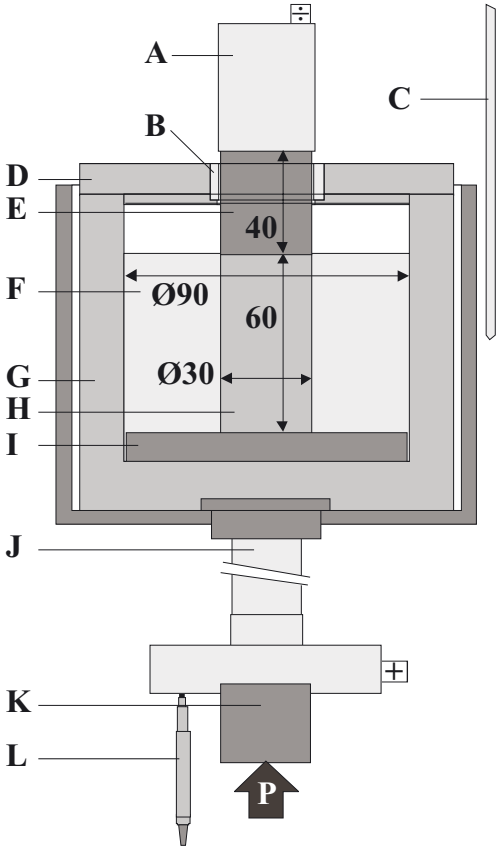
Most of the expansion appears during the first hour of electrolysis. The sodium expansion is smaller the more graphitic the material is. The expansion will decrease with increasing pressure, but the amount of sodium infiltrated is constant. Sodium expansion is also enhanced by adding excess alumina to the bath.



The Figure shows typical expansion curves for different cathode materials for a two hours electrolysis test. The electrolysis starts at time zero.

Experimental

The experimental setup consists of an anodic graphite crucible containing a cryolitic bath with an initial cryolite ratio of 4.0, and with a cathode carbon sample placed in the crucible, as shown in the Figure. The whole sample is immersed in a cryolitic bath and a graphite cylinder is used as an extension from the sample. The crucible is placed in a crucible support, which is connected to a hydraulic power cylinder. A constant pressure of 5 MPa is applied to the sample by pressing the graphite extension against a stop rod in the top of the furnace by the hydraulic power cylinder. The whole assembly is heated in a tubular furnace to (980 ± 5) °C and is then electrolysed for two hours at a current density of 0.7 A cm^{-2}. The expansion is measured by a probe, which is fastened to the frame of the furnace and is measuring the position of the crucible support.



The sketch to the right shows the apparatus for measuring sodium expansion . The abbreviations are:

A – Heat resistant steel stop rod
B – Insulating ring
C - Thermocouple (Type K or S)
D – Graphite lid
E – Graphite cylinder, sample extension
F - Cryolite melt
G - Graphite crucible
H – Sample
I – Alumina disk
J – Heat resistant steel crucible

Reference

D.S. Newmann, O.T. Dahl, H. Justnes, and H.A. Øye, Light metals 1986, 685.

ISO FDIS 15379-1

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