# MONDAY, AUGUST 23, 2004, P.M.

## SESSION 2: FOURTH INTERNATIONAL SYMPOSIUM ON ADVANCES IN REFRACTORIES FOR THE METALLURGICAL INDUSTRIES

ALUMINUM (I)
Sponsors: Materials Science and Engineering, The Metallurgical Society of CIM, The Refractory Ceramics Division of the American Ceramic Society and The Canadian Ceramic Society.
Room: Webster B
Chairmen: C. ALLAIRE, CIREP-REFRAL, Montréal, Québec, Canada, and
L.R.M. BITTENCOURT, Magnesita, Contagem, Brazil

### PAPER 2.1 — 14:00
### REVIEW OF REFRACTORY MATERIALS USED IN THE CATHODE LINING OF ALUMINUM CELLS.

A. TABEREAUX, Alcoa Inc., Alcoa, Tennessee, U.S.A. and
P. BONADIA, Alcoa Alumínio SA, Poços de Caldas, Brazil

Nearly all aluminium smelters are increasing the potline amperage to achieve higher aluminium production. In some instances the higher amperage operation has a significant negative impact on shortening the lifetime of aluminum electrolysis cell cathodes due to loss of the protective sidewall cryolite ledge freeze and too rapid penetration of the cell bottom refractory lining by cryolitic bath components due to the higher temperature isotherms. Thus Cathodes require careful thermal modeling of the cathode relining designs and improved refractory materials to allow greater heat loss from the sidewall to preserve a stable sidewall ledge freeze at higher amperages, and the selection of optimum refractory barrier materials to control the penetration and reaction of bath into the cathode bottom refractory and insulation lining. This requires an understanding of the reaction mechanisms and product formation for molten NaF enriched bath and alumino-silicate refractories. It is desirable to use dense, low porosity refractory fireclay firebricks, or similar materials with a sufficiently high silica content to promote the formation the mineralogical phase albite, NaAlSi3O8, that significantly increases the viscosity of the melt which slows the diffusion of reactive species in the melt and thereby retards further bath penetration.

### PAPER 2.2 — 14:25
### NOVEL MATERIALS FOR ALUMINIUM ELECTROLYSIS CELLS.

W.M. SILVA and L.R.M. BITTENCOURT, Magnesita S.A., Contagem, Brazil

Three newly developed alumino-silicate refractory bricks for use in safety lining of aluminum electrolysis cells were compared to one commonly used bricks for the same application. It was shown that the increase in silica content and decrease in permeability led to a sensitive decrease in cryolite attack. Both parameters are of utmost importance in selecting bricks for these cells. The reasons for this observation were the formation of a more viscous liquid after the reaction between molten cryolite and the brick, and the reduction of the rate of penetration. Moreover, a novel mortar with high silica content was tested and has shown improved resistance to molten cryolite. The use of oxidizing atmosphere led to increased attack rate in the brick when compared to reducing condition. The opposite effect was observed in the mortars.

### PAPER 2.3 — 14:50
### CHARACTERIZATION OF ALUMINO-SILICATE REFRACTORIES FOR ALUMINUM CELLS LINING.

P. BONADIA, Alcoa Alumínio SA, Poços de Caldas, Brazil,
F. VALENZUELA, University Federal de São Carlos, São Carlos, Brazil,
L. BITTENCOURT, Magnesita SA, Contagem, Brazil, and
V. PANDOLFELLI, University Federal de São Carlos, São Carlos, Brazil

Refractories for aluminum cells, if not properly selected, can lead to increased energy consumption and even abbreviate the cell life. Based on the recent advances regarding the understanding of cathode materials deterioration, different commercial bricks in the system $SiO_2$-$Al_2O_3$ were chosen and compared to the one used at an Alcoa smelter. A more realistic method of permeability measurement, along with the traditional cup test and several other characterization techniques, indicated that a low alumina/silica ratio material having not only low open porosity but also less connecting pores far exceeded the performance of the brick currently in use.

COFFEE BREAK — 15:15 – 15:45

PAPER 2.4 — 15:45

INFLUENCE OF SODIUM ON REFRACTORY BEHAVIOUR IN ALUMINIUM PRODUCTION.

O.-J. SILJAN, Norsk Hydro ASA, Porsgrunn, Norway

Refractory materials are an integral part of aluminium production. One special feature of aluminium making is the prominent role of sodium in all parts of the production process. This presence of sodium inflicts stresses on the refractory materials through reactions and may cause severe damages to the refractory linings. The present paper address possible reactions between sodium and refractories in anode bake furnaces, electrolytic pots and casting furnaces. The discussions presented in the paper points to the importance of selecting materials with excellent alkali resistance in all parts of the aluminium making process, although alkali resistance is not the sole parameter to determine refractory life-time. "Acid", i.e. silica-rich alumino-silicate refractories are shown to be the best materials for aluminium electrolysis cell potlinings, whereas high-alumina refractories based on minerals like andalusite seems to be the preferred choice for anode bake furnaces as well as cast house furnaces.

PAPER 2.5 — 16:10

EFFECTS OF SALTS ON THE CORROSION RESISTANCE OF ALUMINOSILICATE REFRACTORIES IN CONTACT WITH MOLTEN ALUMINUM.

E. DAJOUX, S. AFSHAR and C. ALLAIRE, École Polytechnique of Montréal, Montréal, Québec, Canada

For various reasons, molten salts, mainly chlorides and fluorides, are used in the aluminum industry. In the holding and melting furnaces, these salts may have different roles such as protecting the metal from oxidation, reducing the metal content of the skim or removing inclusions or impurities from the metal bath. However, the use of these salts may also have some undesirable effects such as easy attack of the furnace lining refractory materials by molten aluminum.

The aim of the present investigation was to clarify and to compare the effects of chloride versus fluoride salts, on the corrosion process of the aluminosilicate based refractory materials. A laboratory test and procedure, simulating the conditions at the metal line in the aluminum treatment furnaces, was used. Different aluminum alloys (Al-5wt.%Mg, Al-5.5wt.%Zn and 7075 alloy) and chloride or fluoride salts ($MgCl_2$, KCl, $CaCl_2$, NaCl, $MgF_2$, $CaF_2$, NaF and cryolite) were used as well as several aluminosilicate materials. Thermogravimetric measurements were also carried out in order to analyze the effect of the salts on the oxidation of molten aluminum alloys. The experimental results showed that fluoride salts are more aggressive than chlorides against the tested refractory products. It is postulated that the fluorides prevent the formation of a protective oxide layer on the metal surface, favoring at the same time the corrosion of refractories. Moreover, it was found that the presence of Na in fluoride salts increases significantly the aggressiveness of the aluminum alloy towards the refractory samples.

PAPER 2.6 — 16:35

WETTING OF GRANULAR MEDIA BY ALUMINUM.

G. ERGIN, D. KOCAEFE and Y. KOCAEFE, University of Québec at Chicoutimi, Québec, Canada

Filtration efficiency depends strongly on the wetting of the bed media by aluminum. This project was undertaken to study the wettability of different types of bed media (alumina) using sessile-drop and infiltration techniques. The samples were analyzed using optical microscopy, SEM, and TEM to study the chemical interactions. The results indicate the spinel formation at the interface. This paper presents some of the findings which compare the two methods and gives the results of the analyses on the wetting of alumina by aluminum.