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Spent cell linings from the aluminium smelting process as an alternative fuel and raw material for cement production

Aluminium is the most widely used non-ferrous metal in the world, being adopted in almost all industries as well as becoming more and more important for the production of light products with a high strength and durability, eg, aircraft and structural elements, etc. Since aluminium is 100% recyclable, it is widely used for many purposes and is a ubiquitous part of peoples' lives.

Above: The Boyne aluminium smelter in Gladstone, Australia.

The aluminium industry produces around 33Mt of the metal each year. The market leader in terms of its production is Rio Tinto Alcan (RTA), part of the Australia's Rio Tinto Group. RTA produces aluminium in Australia, Asia, Africa, North and South America and Europe.

During the production of aluminium, alumina (Al_2O_3) is dissolved in cryolite inside electrolytic cells or pots, which are steel shells protected by refractory materials and lined with carbon serves as the cathode. A number of cells, usually more than 100, are arranged in series to form a cell line. The cells contain a molten electrolyte consisting primarily of cryolite (Na_3AlF_6) that operates at approximately 930-1000°C.

Over the life of the cathode and its cell lining, the carbon and insulating materials become impregnated with fluoride-containing salts. Failure can occur by cracking or excessive heaving of the lining. When these failures occur, the cell is taken off-line and the cathode lining material is removed from the cell shell by mechanised digging equipment. The spent cathodic material is referred to as spent cell liner (SCL).

MVW Lechtenberg is now developing a sustainable by-products strategy for RTA with the goal to use SCL as an alternative fuel and raw material in the cement industry. For this endeavour MVW Lechtenberg is working from its own office located in Melbourne, Australia, and has already begun advising cement plants and waste producers in the production and use of alternative fuels in Australia.

SCL as an alternative fuel

In addition to containing fluoride salts as mentioned above, SCL contains cyanide compounds that are formed by the ingress of air through openings in the cell shell and subsequent reaction of nitrogen with the carbon lining. SCL is listed as a hazardous waste because it may contain significant amounts of iron cyanide complexes and free cyanide molecules.

The composition of SCL varies considerably. One particular range of analyses is given in Table 1. A process for the treatment of SCL should be versatile enough to treat the SCL generated while using different cell designs, electrolyte compositions and insulation packages. Moreover, any residues generated should meet defined limits for all the constituents of concern (eg, cyanide, fluoride, organics and metals). The components of SCL that pose the greatest environmental concern are cyanide and soluble fluoride salts. One of the principle safety concerns is the presence of water-reactive materials (ie, carbides) that are created during the operational life on the electrolytic cells. Upon exposure to moisture and/or air, these materials liberate explosive gases such as hydrogen, methane and ammonia.

Right: Aluminium smelting cells.

The aluminium industry has long recognised the environmental liability of SCL and has pursued many options for treatment and/or disposal. These options include landfill, recycling as a feedstock in other industries, such as the steel, cement, aluminium, or min-

Alternative fuels and raw materials are attractive propositions for cement manufacturers looking to reduce their costs. However, it is not common that one material can satisfy both demands. However, In this latest dispatch, from Dirk Lechtenberg explains how spent shell linings (SCL) from the aluminium smelting process can be used simultaneously as both an alternative fuel and a raw material. This approach has been used in the Australian cement industry for several years, but MVW Lechtenberg has received backing to export this material for trials in the Philippino cement industry.

eral wool industries, fluidised bed combustion, cryolite recovery, pyrohydrolysis, pyrosulpholysis, and others. Landfill is an option that is presently available but will become increasingly expensive, and eventually may be prohibited, since hazardous waste landfills are required.

SCL – historic use as an alternative fuel in Australia

SCL has been used as an alternative fuel and raw material in the Australian cement industry for several years. A typical process involves adding finely ground (<3mm) SCL directly at the kiln burner or mixing it with coal in the precalciner burner. The following positive effects of using SCL in cement production have been identified in Australian cement plants:

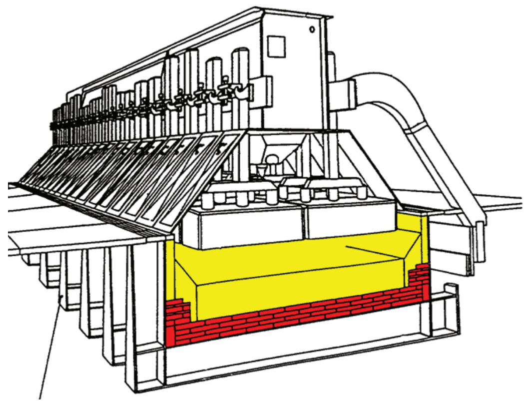
- Replacement of fuel;
- Supply of raw materials such as silica, alumina and ferrous components;
- Lowering of the the burning zone temperature due to the presence of fluorine, which results in additional fuel savings;
- Reduction of nitrogen oxide formation;
- Reduction of CO_2 emissions;
- Complete destruction of cyanides due to the high temperature environment;
- 100% environmental friendly recycling because no residues remain;
- Depending on the transport distance a gate fee for disposal services can be levied.

Due to the typcially high content of alkali in SCL, only a limited amount of SCL can be used in each kiln. As a result, it is not possible for the entire Australian cement industry to use all the SCL produced in Australia. Therefore MVW Lechtenberg is now verifying the export possibilities of SCL to other countries.

Excess capacity – exporting SCL

For the first time in December 2008, representatives of MVW Lechtenberg met representatives of the Philippines' cement industry (Holcim, Cemex and Lafarge Philippines), together with the responsible authorities from the Philippino government – the Department of Energy (DOE), Department for Environment and Natural resources (DENR), Department of Industry (DTI) and the Metro Manila Development Board (MMDA).

Dirk Lechtenberg presented an overview that explained the use of alternative fuels in the cement industry in general. As well as the import of SCL as an alternative fuel source, the use of municipal solid wastes (MSW) from Metro Manila as alternative fuel was also discussed. Cement plants in the Philippines have already begun some small trials with MSW, but up to now have these trials have not received official permission or support from the governmental authorities.



Above: An aluminium smelting cell with carbon lining (yellow) and refractories (red)

The concept described by MVW Lechtenberg's representatives was accepted by the secretary of the DOE, Mr Reyes, and full support was also promised by the other authorities. This constituted a very successful start and for MVW Lechtenberg's activities in the Philippines! More infornation about the use of alternative fuels in the Philippino cement industry will be discussed in a future issue of *Global Cement Magazine*.

Table 1 (below): Typical composition of spent cell liners (SCL).

Material	Composition
Carbon cathode	15–30%
Refractory slabs and bricks	30–40%
Vermiculite and calcium silicate board	5–10%
Silicon carbide bricks	2–5%
Absorbed catholyte (bath-like material)	15–25%
Carbon	15–30%
Na2O	14–20%
K2O	0.4–0.8%
Fluorine	9–15%
Al2O3	25–35%
SiO2	14–20%
Fe2O3	1–3%
CaO	1–3%
Moisture	0.5–2%
Net calorific value	5–18GJ/t
Sulphur	0.05–2%
Chlorine	0.01–0.04%
Total cyanides	0.01–0.1%

The next steps

MVW Lechtenberg will now apply for export and import licences according to the Basle convention, which is expected in April 2009. SCL will be then finely ground and transported in specially designed 'hazardous goods' silos for safe and environmentally friendly transportation in order for trials to begin in the Philippines.

Since SCL are also available from aluminium smelters in other countries, MVW Lechtenberg has developed a product information folder with all related information for the use of SCL as an alternative fuel in the cement industry, which is available by request from the author at D.Lechtenberg@lechtenberg-partner.de.