Recent Research Activities of Nonferrous Metallurgy at the University of Miskolc/Hungary

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Since its foundation in 1870 in Schemnitz the higher educational and research centre of nonferrous metallurgy in Hungary has gone first to Sopron after the First World War and then to Miskolc in the fifties of the last century. During its 135 years existence the Department of Nonferrous (Extractive) Metallurgy as a knowledge base has undergone conceptual transformations in its teaching and research domains before it has now become part of the recently established Department of Metallurgical and Foundry Engineering (Group Nonferrous Metallurgy) at the Faculty of Materials Science and Engineering at the University of Miskolc. The mission of its staff, however, has not changed much during its long history and geographical transfers, and still the group’s members are striving hard to serve the intellectual needs of the students and to fulfill basic and applied research activities for the nonferrous primary and secondary industry in Hungary. Moreover, and in parallel to that, the research efforts have always been carried out in view of the international tendencies and often in close collaboration with foreign institutions, e. g. from Leoben/Austria, and Sendai/Japan.

1. Research Activities in Connection to the Bauxite Processing in Hungary

Hungary is still one of the most important producers of alumina and aluminium metal in central Europe, and the Bayer type processing of bauxite ores and the aluminium industry as a whole has been an important sector of the nonferrous industries of the country. Moreover, in the last two decades the Ajka works of the Hungarian Aluminium Company (MAL) has expanded considerably its production portfolio and in Europe it has become a major producer of some special products like the very fine particle size aluminium trihydrate (ATH) precipitates, synthetic zeolites, special grade aluminas, and high purity gallium metal. (See Fig. 1.)

Also in the last couple of years the former Department of Nonferrous (Extractive) Metallurgy of the University of Miskolc has strengthened its research and development collaboration activities with the R&D units of MAL’s Alumina Plant in Ajka. For some years the ultra fine grade ATH precipitates, being produced in the new batch type crystallizers, have become a very important high-tech product, of which the particle size distribution, shape factors, powder’s flowability and other physical properties must be controlled within very narrow ranges. By using the appropriate tools of mathematical statistical analysis, the collaborating partners could identify and evaluate those most significant parameters. By means of their proper control it has become possible to improve the quality of that special product.

In connection also to another unique product of the Ajka Alumina Plant of MAL, a departmental laboratory research project was aiming at developing an alternative extraction route of gallium from the sodium aluminate process liquors by means of using an alkylated hydroxyquinoline extractant (Kelex-100). This liquid-liquid extraction step could then be followed by a complex purification procedure, now in aqueous chloride media, by means of using anion exchange resins2.

The Group Nonferrous Metallurgy, in co-operation with one division of the Ajka Alumina Plant and its Central Testing Laboratory, has conducted basic studies and several laboratory grinding experiments in order to improve the size distribution and sinterability of some selected and important special grade fine alumina products of the company. It was proved in several laboratory grinding experiments that the ground ball mill products of

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the carefully selected and properly mixed aluminas showed much better flowing (i.e. much less glutinous) and other high quality characteristics than any of their constituents alone. Also the proportions of the components had to be optimized in order to develop a new product with higher added value, which should be much more competitive with its counterparts in the world alumina market as well. Concurrently with the laboratory experiments several technical improvements have also been developed, tested and introduced in the industrial ball milling plant in Ajka. During these production experiments, all possible technical data were systematically measured and collected for further analysis and in order to be able to design a new technology of producing super-fine ground special grade aluminas in the newly installed grinding section of the plant.

2. Recycling and Treating Metals and Metal Containing Wastes

The Hungarian alumina plant in Ajka, like all the others in the world, produces red mud waste which is highly alkaline with pH > 12. The worldwide increase in the tonnage of red mud is dependent on the mineralogy of bauxite used in the Bayer process. In a recent international collaborative investigation of the partners from the UK and Hungary, who compared the mineralogy of red mud samples obtained from ALCAN in Scotland, INDAL in India, and MAL in Hungary, it was found out that the mineralogy of Hungarian red mud was very different from those of ALCAN and INDAL. The titanium dioxide concentration of Hungarian red mud is much smaller than that found in ALCAN and INDAL red mud. In this research work the soda-ash roasting of red mud and bauxites in air in the temperature range of 623–1123 K was also studied in an attempt to design a zero-waste process. The roasting reaction results in nearly 100 % yield of sodium aluminate, for example at 1050 K and at soda-to-alumina ratio in the red mud/alkali mixture. The time and temperature dependence of the yield of water-soluble sodium aluminate (NaAlO₂) was established for designing a low-temperature sodium aluminate manufacturing process, which will be compatible with the Bayer alumina refinery operation.

Both, the smelter grade liquid aluminium and that one obtained from melting down metallic scrap of any aluminium alloy, require special treatment in order to reduce their impurities. One industrial purification treatment of molten aluminium is based on the principle of flotation (to collect and remove the suspended solid particles) in combination with the degassing effect of the floating inert gas bubbles (argon or nitrogen) to decrease the levels of dissolved gases (first of all hydrogen) of the melt. In order the increase the efficiency of the industrial equipments, small plastic laboratory model cells, similar to the ones used in the aluminium industry in Hungary (MAL, ALCOA, etc.), were built at the university department and operated with purging nitrogen into water. By varying different parameters (type of nozzle, geometrical dimensions, speed of rotation, etc.) and measuring the bubbles' distribution and the concentration of dissolved oxygen, the data so recorded then served for establishing a computer simulation model. Using that mathematical model, it is envisaged to be able to further improving the performance of the industrial machines working at different conditions.

These days, the secondary steel industry fed by scrap and working with electric arc furnaces (EAF) is producing huge and ever increasing amounts of EAF dusts with high zinc oxide and zinc ferrite content. Based on a few series of small scale (pilot plant) experiments at the BÉM Co., our research team was looking at the technical feasibility of the removal and recycling (by means of evaporation and condensation) of the zinc content of such waste product working with a static bed roasting system. The reductive roasting approach was found relatively effective, but even a modified Dwight-Lloyd type