Introduction

The growth in China’s economy over the past decade has driven fundamental changes into its commodity supply chain. Bauxite to aluminium is a good example. The annual global production of primary aluminium has increased from 25 million tonnes in 2000 to 45 million tonnes in 2012, an average growth rate of 5.2% per year. Over the same period China’s annual aluminium production grew from 3 million tonnes to 20 million tonnes, an average growth rate of 18% per year. This is in marked contrast to the corresponding figures in Western Europe, North and South America, where production has decreased. In 2012, China produced 44% of the global total, up from 11% in 2000. China has also carried out extensive R&D work to improve not only production and productivity in their existing alumina refineries and smelters but also enable produce scores of value added products of bauxite, alumina and aluminium and developed new technologies comparable to the best in the world at very low costs – both Capital and Operating. In the present depressed alumina-aluminium market scenario in the world, it is necessary to evolve ways and means to improve the economics of existing plants through concerted R&D efforts. In this connection, the experience of Chinese aluminium industry in achieving this high growth rate at minimal capital and operating costs is the subject of wide interest and should be a learning curve for industry all over the world.

China has rolled out new standards for the alumina and aluminum sectors effective from July 2013, which includes setting underlying bauxite supply requirements and minimum capacities for new projects. The new measures taken by the Ministry of Industry and Information Technology (MIIT) of China are aimed at preventing unlicensed mining and wastage of resources, accelerate the restructuring of the aluminum sector and monitor smelters' expansion.
Keeping in view this excellent growth of aluminium industry in China, a symposium is being organised by the International Bauxite, Alumina & Aluminium Society (IBAAS), China Aluminum International Engineering Co., Ltd. (CHALIECO) and ANTAIKE to show case the technological developments and also interact with the concerned engineers, technologists & scientists who made all this happen. The Symposium has been planned with the following objectives:

- To review the promising R&D activities aimed at improving production and productivity in the existing bauxite mines, alumina refinery and aluminium plants.
- To highlight the proposed Greenfield activities of aluminium industry in the world with special reference to Asian countries.
- Latest technological developments in the field of bauxite beneficiation, alumina production, aluminium smelting, non-metallurgical bauxite and special alumina and aluminium products.
- Import and export potentials of bauxite, alumina and aluminium in China and other Asian countries
- Market and price trend of bauxite, alumina and aluminium and their products.
- Non-metallurgical applications of Bauxite and Alumina
- Market and price trends of calcined bauxite for refractory/abrasive industry, alumina cements, brown & white fused alumina, special alumina and all types of alumina chemicals.
- Latest technological developments in aluminum downstream industry.
- Market and price trends of Aluminium downstream products

The Symposium will provide an excellent opportunity to meet and interact with International experts, scientists, engineers, entrepreneurs, representatives of bauxite-alumina-aluminium industries world over including multitude from the host country. The conference will be held during November 28-30, 2013 in Nanning city in South China and further details can be obtained from website [http://www.ibaas.info/](http://www.ibaas.info/).

### 2. Bauxite for Alumina Refineries

China’s bauxite prospecting has been picking up pace over the past three years. This is due to growing demand for domestic bauxite from rising alumina capacity in China and risks of raw material shortages from heavy reliance on imported bauxite. According to data from the Ministry of Land and Resources, China’s proven bauxite reserves grew 210 million tonnes to 4.08 billion tonnes in 2012 rising for 3 years in a row. Proven bauxite reserves across China totaled 3.55 billion tonnes in 2009.

China’s bauxite features poor quality and limited resources of high-quality metallurgical bauxite. With the gradual release of new alumina capacity and expansion of downstream smelting capacity in the country, China has rapidly increased the import of bauxite. China’s imports of bauxite mainly come from Indonesia, Australia and India, among which, Indonesia accounts for more than 70%. The supply of bauxite from non-China sources ramped up after 2004, from 1 million tonnes in that year to 40 million tonnes in 2012, an average growth of 61% per year (Fig.1). Further increase in bauxite imports in China is forecasted.
3. Non-metallurgical Bauxite Industry of China

Both bauxite and alumina are used for non-metallurgical applications, and in these sectors growth prospects are more mixed. Refractory grade bauxite is predicted to have moderate growth over the next five years, largely linked to the fortunes of the iron and steel industry, while markets such as proppants will exhibit a stronger growth profile, due to the expansion of shale gas production. In China, there are several companies producing various qualities of sintered bauxite (Proppants) for oil and gas exploration.

While China’s economic growth stabilises, the country’s demand for bauxite and fused alumina for refractory applications in steel production continues, and can be viewed as responsible for initiating several new projects in the bauxite-rich provinces of Henan, Guizhou, and Shanxi. In Guizhou province, the Chinese Bureau of Geology and Mineral Exploration and development has discovered a 100 million tonne bauxite resource in Zheng’an County, associated with coal deposits. This follows an earlier large bauxite find in Dazhuyuan, Wuchuan County, Guizhou. The average thickness of the visible deposit is 1.8 metres, and the average grade is 56% Al₂O₃. This meets raw bauxite specifications for abrasive and chemical-grade bauxite. Here the significant feature is the very low ferrous contents. In China usually the bauxite of refractory grade is higher than 60% Al₂O₃. A part of this ore may also be used as sweetener to low metallurgical grade bauxite.
Concerns remain in the industry over the availability and security of supply of calcined bauxites, as there are relatively few big producers outside of China. New sources of supply and expansions in Guyana and Brazil may ease fears of future shortages going forward. European supply of non-metallurgical bauxites has increased over the last five years, mainly through growing production in Greece, Turkey and Russia.

4. Alternate Source of Alumina

There have been several attempts in the last decade in China for processing fly ash to alumina and its by-products. Various processes are evolved in China to extract alumina from fly ash; some of them are as follows:

- Lime stone sintering process
- Soda lime sintering process
- Sulphuric acid process
- Ammonium sulphate process
- Alkali and acid combination process

The ammonium sulfate method is given more attention and active recommendation. Nowadays, as the bauxite resources become gradually rare in China, it is an efficient way to extract valuable materials, such as alumina from the fly ash and provide a highly comprehensive utilization for the fly ash, which offers great social and economic benefits.

Basing on above processes, the alumina pilot plants have been built in order to guide the construction of refinery which extracts alumina from fly ash. There is an alumina refinery using fly ash in Inner Mongolia. Fly ash is the biggest industry pollutant in China, at the same time there is a great amount of alumina in fly ash. Typical composition of Chinese fly ash is shown in Table 1. Extracting alumina from fly ash should be a strategic way for Chinese alumina industry in the future.

| Table 1: Fly ash quality of China (ranges of chemical components) |
|-----------------|---------|--------|--------|--------|---------|--------|---------|---------|
|                  | SiO₂%   | Al₂O₃% | Fe₂O₃% | CaO%   | MgO%   | SO₃%   | Na₂O%   | K₂O%    | LOI%    |
|                  | 34-66   | 15-40  | 1-16   | 1-17   | 0.2-4  | 0-6    | 0.1-4   | 0.1-2   | 0.6-30  |

In spite of the claims of the investigators in the field, on the effectiveness and high level of technical attainment and the public announcement of “huge” construction plans, it appears that a mature and readily applicable technology of extracting alumina from fly ash still requires more efforts. As for new alumina projects using aluminum-rich coal fly ash, the new guidelines are: a minimum capacity of 500,000 mt/year, Alumina Refineries to process this must be located near the coal fly ash production zones and that the supply of coal ash must be ensured for "not less than three decades."

Nepheline Syenite is another important source being considered for alumina extraction in China. Limestone sintering process is the typical process for dealing with nephelite; the latter was used to refine alumina for a long time in Russia. Typical composition of nephelite in China is shown in Table 2. As of now there is no nephelite processing refinery in China. Low grade bauxite and non-bauxitic resource will be more and more important for Chinese alumina industry with the decreasing bauxite quality.
Table 2: Nephelite quality of China (ranges of chemical components)

<table>
<thead>
<tr>
<th>SiO₂%</th>
<th>Al₂O₃%</th>
<th>Fe₂O₃%</th>
<th>Na₂O%</th>
<th>K₂O%</th>
</tr>
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<td>48-59</td>
<td>17-23</td>
<td>2-5</td>
<td>4-10</td>
<td>3-11</td>
</tr>
</tbody>
</table>

5. Alumina Production in China

In 2012, production capacity of alumina in China reached 54 million tons. Under the influence of economic growth slowdown and macroeconomic regulation for real estate in China, alumina consumption growth was slow. The output of alumina in China accounted for 39.51% of global output, and China’s consumption accounted for 45% of global consumption. China has become the world’s largest country for production and consumption of metallurgical grade alumina, and the primary strong country in alumina industry with a stride forward towards the goal of being excellent. The phenomenal increase in alumina production in China during 2001-2012 is shown in Fig.2.

![Fig.2: Alumina Production in China from 2001 to 2012](image)

China uses various processes to produce alumina and among them Bayer, serial combination and dressing Bayer process are comparatively cheaper than sintering and mixed combination process. For middle and low grade bauxite (Alumina & Silica ratio 4–6), combination process is found realistic for technical reconstructing and production organization. This is the reason China is able to process any quality of bauxite even with high silica. The regular export of high silica bauxite (up to 8 to 10% SiO₂) from India (Gujarat and Maharashtra) and Indonesia are evidence of availability of better alumina processing technology in China. Normally this quality bauxite is not acceptable by Indian alumina refineries, because they use the Conventional Bayer Technology, which cannot economically process the high kaolinitic silica bauxite.
6. Special Alumina

Around 6% of the total alumina produced in China is of chemical grade. This is then split between calcined alumina and speciality grade alumina markets, which includes alumina trihydrate (ATH). Calcined alumina is used in a wide spectrum of end uses with the total market forecast to grow to 3.1 million tonnes by 2017. Alumina Tri-hydrate (ATH) is either used in speciality applications such as fillers and flame retardants or as commodity grades used in water treatment, zeolite manufacture and in aluminium fluoride. Roskill forecasts growth for ATH markets, especially in water treatment and flame retardant markets to take the total market size to over 4.6Mt by 2017. Again China is leader in the production of speciality aluminas.

7. Aluminium smelting

China, since the late 1980s, has worked tirelessly to perfect its aluminum production skills. It has now one of the world’s best aluminum production technologies. For example, mature 500kA pots are used in a very large number, it is reported that the DC power consumption can reach 12.xx kWh/kg and low capital cost level helped the large scale construction. Global production of aluminium has grown by an average of 6.6% between 2002 and 2011, but in China it has grown by 18.4%. However, consumption has grown by a slightly more modest 5.9%. Inventories overhang the market, and throughout 2013 the industry will be stretched by rising production costs and low prices.

The remarkable increase in Chinese aluminium metal production during 2001 to 2012 is shown in Fig. 3.

![Fig.3: Aluminium Metal Production in China from 2001 to 2012](image-url)
8. Concluding Remarks

The phenomenal growth of bauxite, alumina and aluminium industry in China and R&D achievements are learning curve for other countries especially for India, Indonesia and Vietnam which have the required good quality resources and huge market potential for the same. A thorough examinations needs to be carried out on the possibilities of utilising the widely available fly ash, which are otherwise environmental hazard. The present restrictions being imposed by Government in China may partly slow down the ever expanding alumina and aluminium production in the country. Despite this present malaise, the aluminium industry is positive about its future, predicting rising consumption growth through to 2020, mostly due to increased industrialisation and urbanisation in emerging economies.

The IBAAS-CHALIECO-ANTAIKE symposium will provide an excellent opportunity for scientists, engineers, planners and equipment manufacturers to interact with Chinese aluminium industry representatives. Further visits to bauxite mine, alumina refinery and smelter of China are being organised for delegates of this symposium, to have a first hand view of the facilities and understand their construction and operation specialisations. Please contact info@ibaas.info and visit web site: http://www.ibaas.info/ for details.

References


- China’s Growing Appetite for Bauxite By Jim Marron, SALVA Report, August 6, 2013