Supply and Demand of High Alumina Raw Materials for Refractories in Europe

A. Buhr, O. Koegel, J. Dutton

Refractory production and high alumina raw material demand in Europe are estimated, and the supply situation for different raw materials is discussed. Because of changes in the supply of Chinese based raw materials, the development of strategic alternatives for the European refractory industry has become an important topic. Different alternatives are discussed and special focus is given to the subject of partnership between raw material suppliers, refractory producers, and end users of refractories. This partnership is essential for the success of projects to develop new alternatives.

High alumina refractories in Europe

The demand for high alumina refractory raw materials in Europe has been assessed based on PRE statistics [1] and other considerations. About 5 Mt of refractories are produced in Europe annually of which 30–40 % is exported. About 1,1 Mt are considered to be high alumina refractories (>55 % Al_2O_3; Fig. 1). The annual consumption of refractories in Europe is about 3,8 Mt, 10–20 % of which are imported, mainly from emerging markets. Chinese annual refractory production is estimated at 28 Mt, but in the mid-term, internal demand for Chinese raw materials will influence raw material exports to Europe.

Refractory bauxite has the highest share of the market. It is imported from China and from South America, where refractory bauxite resources are now owned by the Chinese. The next highest consumption is Andalusite plus some kyanite from the sillimanite group of minerals (Al_2SiO_5). Andalusite is sourced from South Africa and Europe, and supply seems to be secured for the foreseeable future by investment in new sources or the extension of existing ones. Brown Fused Alumina (BFA) is produced from low iron calcined bauxite by fusion in an electric arc furnace at temperatures above 2000 °C. China accounts for about 80 % of global BFA supply. Tabular alumina and White Fused Alumina (WFA) are produced from synthetic alumina feedstock, and consumption of tabular alumina in refractories is higher in Europe when compared to WFA. Supply of these materials, and also mullite and mullite-chamotte is not dependent on supply from China and is not considered to be subject of supply constraint in the foreseeable future. Technical and economic aspects of high alumina materials for steel refractories have been discussed in detail by Buhr, et al. [2].

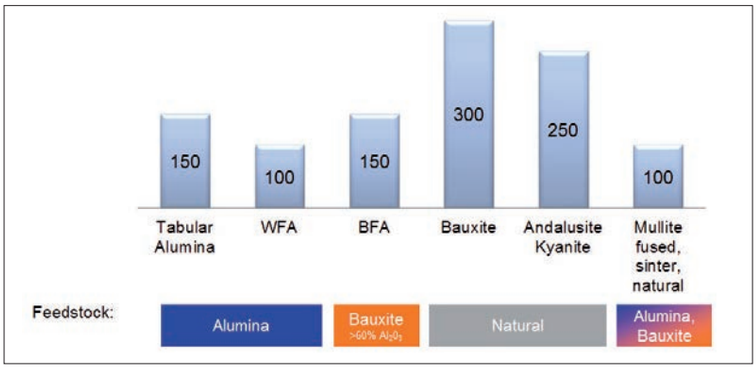

Fig. 1 Consumption of high alumina materials in Europe [kt/a] (estimated in steps of 50 000 kt/a)

Development of refractory bauxite

Prices for refractory bauxite and BFA have increased considerably since 2007 when compared to the other high alumina raw materials (Fig. 2). It is necessary to consider the development of refractory bauxite over the past two decades in order to understand these changes. In the 1990s, low priced Chinese refractory bauxite was introduced into the global market and replaced alumino-silicates in some applications. This led to the decrease in consumption of andalusite and

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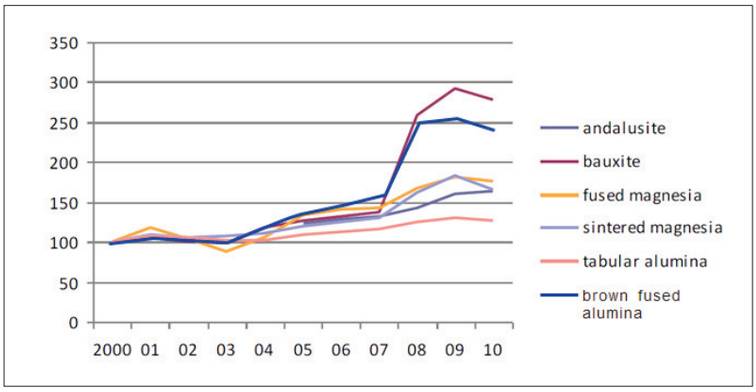

Fig. 2 Price development (using 2000 as base) of high alumina raw materials during the past decade [3]

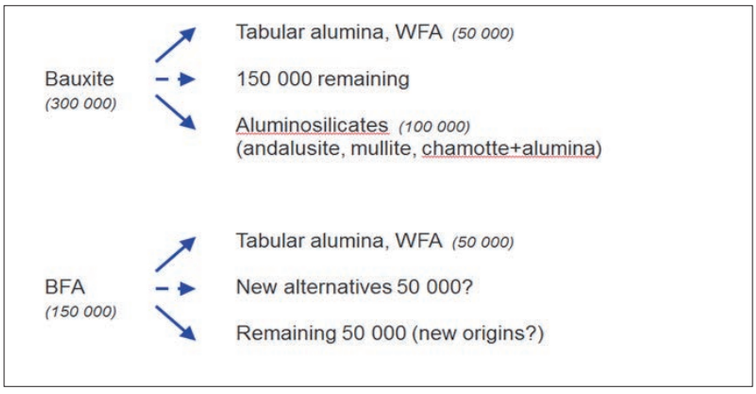

Fig. 3 Alternatives to bauxite and BFA in Europe (estimated in steps of 50 000 t/a)

mullite-chamotte in Europe. It also drove Brazilian bauxite producer MSL out of the market and the same almost happened to Linmine from South America. Therefore the dependency of European producers on Chinese bauxite increased. This dependency was also the case for BFA.

During the 2000s the situation changed. The tremendous growth of steel production in China significantly increased the internal demand for refractories and raw materials. The policy of the Chinese changed from supporting raw material export to actively discouraging it [4]. Bauxite and BFA exports from China have been limited in volume by export licenses and are now subject to taxes and fees. This has resulted in steep price increases in the world market. Conversely refractory product exports from China are not subject to such limitations. The European refractory industry is now challenged to establish alternatives, both from an availability and also from a strategic point of view. Today about 300 kt of refractory bauxite and 150 kt of BFA are imported annually to Europe from China and Guyana (Chinese Bosai group). The pricing of these products is now following economic standards.

Alternatives to Chinese bauxite and brown fused alumina

When considering technical alternatives to refractory bauxite and BFA, higher or lower alumina raw materials can be chosen depending upon the specific application. For some applications, however, the technical requirements would mean that the existing refractory solution would still be needed. For the European market, the options for such changes have been roughly assessed as shown in Fig. 3.

Tabular alumina and WFA are the higher alumina alternatives, and sufficient capacity is available in Europe from various suppliers: Tabular alumina from market leader *Almatis,* or *Alteo* and *Silkem,* WFA from *Treibacher Schleifmittel, Motim, Alteo, Boxitogorsk,* or from China. These materials are based on synthetic Bayer alumina. They have a higher price but also provide better performance in many applications, resulting in lower specific refractory consumption and lower specific costs [2].

Lower alumina alternatives can also provide equal, and sometimes even better technical performance in selected applications [2] and their supply in Europe is practically independent from China: Andalusite from *Damrec* South Africa and France, *Andalusite Resources* in South Africa and *Andalucita* in Peru. Kyanite is supplied from *KMC* in the US. Capacity increases have also taken place here during the past years [5]. Mullite and mullite-chamotte materials are supplied from *CE Minerals* in the US, *Motim* in Hungary, *Nabaltec* in Germany, and *Treibacher Schleifmittel.* For some applications lower price chamottes can even be an option *(AGS* France, *VKV* Ukraine, *Cluz* Czech Republic, and others). Lower alumina chamotte materials can be upgraded by alumina addition depending on price and quality expectations.

New alternatives have already been developed or could be considered. The sintered aggregate BSA 96, which was launched in 2010, is produced in Germany and is not dependent on Chinese raw material [6]. It has proved its performance in the meantime e.g. in blast furnace runner linings, steel lances and bricks. Production of BFA outside China may be re-established sometime in the future. However, at the moment, market prices are too low to justify this, and rising energy costs are critical especially for the fusion process which has a higher specific energy consumption when compared to the sintering process. In addition the sourcing of suitable low iron bauxite independent of China would be mandatory. New technologies for the purification of iron-rich metallurgical bauxite to give the required alumina content for refractory grade bauxite are under consideration [7].

Synthetic alumina sourcing

When considering the sourcing of alumina raw materials strategically, it is important to distinguish between refractory bauxite and metallurgical bauxite based materials (Fig. 4). The dependency of the world market on Chinese or South American refractory bauxite sourcing has already been discussed. Synthetic alumina based materials such as tabular alumina, are based on so-called Bayer alumina, which uses metallur-

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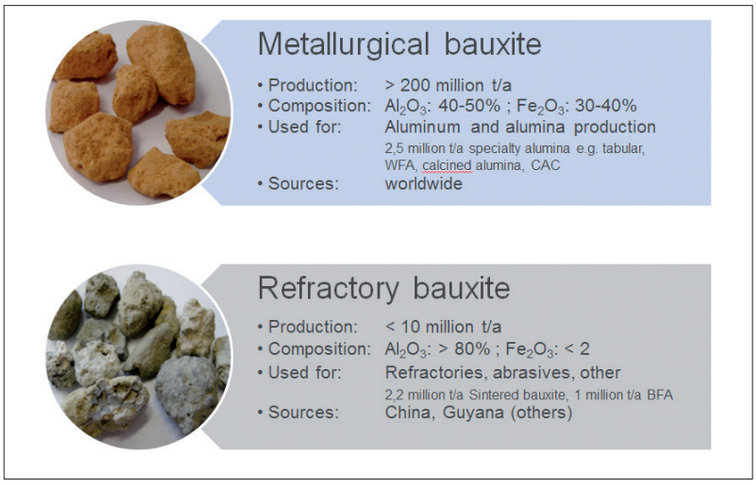

Fig. 4 Metallurgical and refractory bauxite

gical bauxite as feedstock. Metallurgical bauxite is mined worldwide and volumes are much higher than for the special low iron refractory bauxite, which is also used in other markets such as abrasives (Fig. 4).

More than 90 % of Bayer alumina is consumed in the production of aluminium. As in the case of steel, over the past decade, China has become the biggest worldwide alumina and aluminium producer. However, in terms of total bauxite reserves China accounts for only 3 % of the global reserves of 29 000 Mt [8]. China has become dependent on imports of metagrade bauxite. Metallurgical bauxite mining and Bayer refinement is carried out on all continents and therefore supply of Bayer alumina for synthetic alumina refractory raw material production is independent from China. These materials provide a strategic alternative.

Synthetic alumina raw materials often have special requirements with regard to their Bayer alumina feedstock. A distinction is made between so-called metallurgical and chemical grade alumina. In Europe, alumina production accounts for only 6,4 % of global metallurgical alumina but for 29 % of global chemical alumina production [9]. Therefore the feedstock supply for synthetic alumina based refractory raw materials is strategically secured.

Development of new alternatives – partnership is "key"

All projects for the development of new raw material alternatives require a long-term strategy and considerable investment. This is obvious for new mining projects – from initial exploration, then the development of the mine through to the construction of suitable infrastructure such as rail, roads, or even new ports. In addition, environmental aspects will require the involvement of, and close cooperation with, the local governments. Often such new mines are in remote areas where it is not easy to get skilled people as a workforce and intensive training and education are necessary. Such large industrial facilities have substantial energy requirements and the energy companies will only commit to supply when long-term volume contracts are in place. Such contracts can become a big challenge when delays occur and supply is required later than that stated in the initial business case. For example if the market development of the new product starts later than predicted and the contracted volumes are not yet required. Sound business cases are required for such big projects.

The development of new aggregate raw materials takes place on a lower economic scale when compared to new mining projects. However, such projects can also require considerable investment before an economically suitable new alternative can be offered to the market. Cooperation with customers should start in the very early stages of the project, to define the market needs and future requirements, including technical specifications of new materials. In order to make a new alternative strategically viable, the access to suitable feedstock material on a long term must also be clarified.

The development and qualification of new materials requires extensive research and development work for both raw material supplier and refractory customers. Industrial up-scaling of the laboratory work should also involve the end users. Therefore the timeline for introduction, qualification and market penetration of new products can easily be several years. This must be taken into account when defining the business case and considering investment in new processing units. These are often required for technical reasons or to avoid cross contamination with other existing production.

For example, *Almatis Ludwigshafen*/DE has invested more than USD 6 million in a new 30 000 t/a crushing and sizing facility for different high alumina aggregates. This was mandatory for the cost effective production of the new sinter aggregate BSA 96. Another example of cost involved with product development is the up-scaling of laboratory work on new sinter aggregates by pilot trials in existing production units. These are required to validate laboratory results and, just as important, to provide sufficient crushed and sized material for product development and application test work at the refractory customers. Such trials can easily cost a 6-digit USD sum, with no advance guarantee that marketable material will be produced. It therefore becomes clear that even smaller scale development projects to produce new raw material alternatives require sound business cases to limit the economic risk.

We must now ask what must be a fundamental part of such business cases besides the usual considerations of product definition and analysis, market and competitive analysis, technical and operational assessment, risk analysis, and financial assessment? It is the close cooperation with refractory customers and a clear commitment of those customers to support the new development in order to finally achieve rewarding business for all partners involved!

It must also be emphasised that such a partnership approach is not only limited to raw material suppliers and refractory producers. For the costly development of new raw material alternatives, which are driven by strategic considerations of long term secured sourcing, it also requires the commitment and partnership of the end users of refractories. High alumina refractories or high quality refractories in general are essential for the production of high quality steel and also for other industries such as cement,

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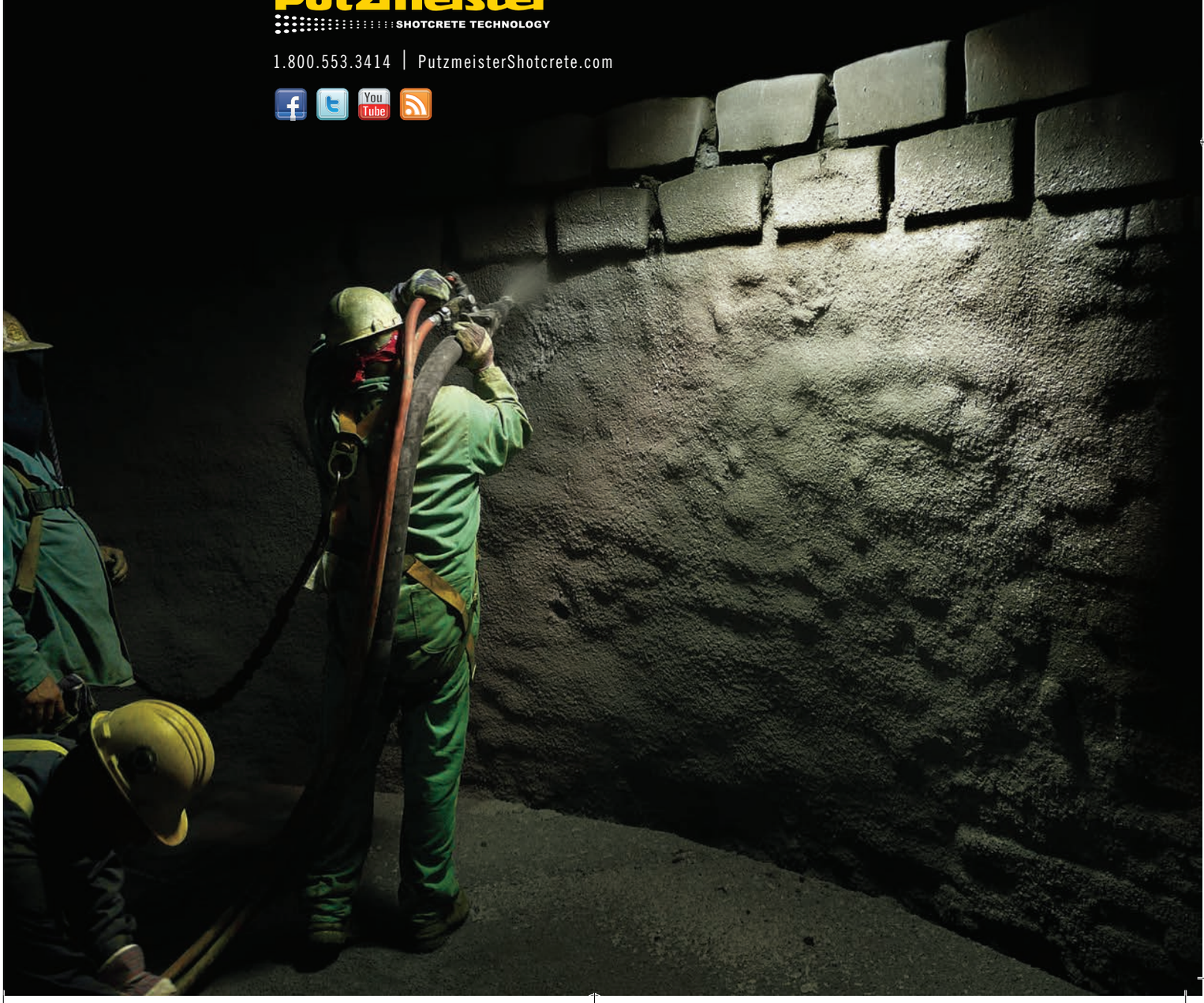

glass, petrochemistry, incineration etc. Often product and process improvements e.g. in the manufacture of steel, are only possible with new, improved refractory materials. The close cooperation with competent and experienced refractory suppliers in the European region is seen as fundamental for the long-term success of such end user industries.

It was mentioned before that, at this time, export of finished refractory products from China is not subject to licenses, taxes, and fees. These only apply to export of raw materials. This can provide economic advantages for Chinese refractory producers selling their products in the European market because they can take advantage of lower priced raw material sourcing. Import of Chinese refractories may be a short-term strat-egy for refractory end users to overcome cost increases due to rising raw material costs for bauxite and BFA. However, due to rising internal Chinese demand and potential changes of export policy in the future, this is not expected to be a mid or long term solution. In addition such purchasing strategy in Europe may risk the existing supply infrastructure in the European region and threaten the potential for future technical development in refractories and end user processes.

Function of traders

Raw material traders play an important role for raw material sourcing abroad. Here, the lead time is a key factor in the supply. Producing refractories on specific demand is driven by cash flow issues and a buyer´s market. Raw materials are only ordered for specific projects. Lead times for raw materials supplied from overseas can be up to four months, and often traders provide the stocking required for short term availability and also the financing of these stocks. In the recent economic crisis, risk management has become an issue and stocks are an important part of it. Financing of stocks requires a predictable price level for the products and reasonable supply contracts with the refractory customers. It is obvious that there is a conflict between a reliable short-term supply and purchasing at spot market prices. The raw material trader´s involvement in the business may be reduced because of limited commitment by the customers. It is questionable if a trend towards a spot market would provide better economic results for the refractory customers, when orders and business could be lost because of a lack of raw material supply.

Conclusion

The European refractory industry is importing about 40 % of its high alumina raw material requirements from China in the form of refractory bauxite and BFA. Steep price increases since 2007 and concerns around the mid and long term availability of these materials have triggered the desire for strategic alternatives. Such alternatives exist to some extent in higher or lower alumina content materials, which can be sourced in Europe or other regions independent from China. However, in addition to these products, new alternatives need to be developed. Some new materials have been launched in the recent past or are currently under development. Projects for new raw material mining, but also for new materials within the existing infrastructure, are capital intensive and require a long-term strategic approach. Partnership between raw material suppliers, refractory producers, and refractory end users is essential for such projects in order to provide sound business cases for the investments and to achieve the desired strategic alternatives for the European refractory industry. A competent and experienced local refractory industry is important for the future development of high temperature processes in many industries in Europe. Even in a tough economic environment, business is made between people, and reliable and strong relationships are becoming even more important.

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