Riedhammer GmbH

Baking furnaces for anodes of highest quality

Riedhammer GmbH with headquarters in Nuremberg, Germany, has many years’ experience in the carbon business stretching right back to its founding in 1924. The company’s reference list is impressive: it includes well over 200 orders for furnaces for producing electrodes, cathodes and anodes. The largest complete order to date was received in 2008; it was for an anode baking furnace for the Kazakhstan Aluminium Smelter (KAS) and the project was finalised in 2012.

Until the middle of the last decade, Riedhammer had specialised in closed-type anode baking furnaces. Following its acquisition of open-top technology from Alesa in 2005, Riedhammer is the only independent company worldwide that supplies both open-top and closed-type anode baking furnaces. Today, open-top ring pit furnaces are the predominant system for new projects but there are still a lot of closed-type anode-baking furnaces in operation worldwide that Riedhammer repairs and modernises, or can rebuild as open-type furnaces if required.

The company completed such a conversion at Trimet in Hamburg in 2011. “That was a very interesting project for us,” explains Thomas Janousch, business unit director of the Carbon Division at Riedhammer. “It was a complete order covering not only the engineering but also the supply of materials and the execution of the refractory lining on site. The project was completed in record time: the existing furnace tub was demolished in April and the furnace, including construction of the tub and extension of the foundations was completed in December.”

The new 48 section anode-baking furnace increased the capacity of the Hamburg Trimet carbon plant by 50 percent, to 120,400 tonnes a year. It is capable of supplying high-quality anodes to Trimet’s smelters in Hamburg and Essen. The furnace has six pits per section, three fire groups, a fire cycle time of 26 hours and is fuelled by natural gas.

Carbon is the most important area of business at Riedhammer, accounting for some 30-50 percent of turnover depending on the actual project situation. Within the Carbon Division, the anode sector accounts for the largest share of the business, or at least has done so in recent years. Riedhammer’s corporate structure enables the company to react very flexibly to large orders. As and when required, the division can call upon the resources of other technical departments.

Riedhammer’s carbon business comprises three business units: Anodes (mainly open-top baking furnaces for anodes of highest quality), Electrodes/Cathodes (closed-type baking furnaces) and, more intensively since 2011, Special Carbon (here Riedhammer offers car bottom furnaces or small closed-type ring pit furnaces). “An added reason why the Special Carbon business is interesting for us is that we can call upon the expertise of our Technical Ceramics division when it comes to the car bottom furnace (second firing of electrodes). As the anode business is very cyclical, this ensures a steady order intake and an even workload in the department,” says Mr Janousch.

Whereas the electrode business is geared to the steel industry, cathode baking furnaces are used to produce the cathodes used in aluminium electrolysis. This is a limited business because unlike anodes, which are consumed continuously during the electrolysis process, cathodes have a service life of several years.

Range of contracts: from modernisation projects to installation of complete units

The most extensive contract involving a Riedhammer anode baking furnace comprises the whole of the engineering with the associated specifications, the supply and installation of the refractory materials for the furnace and all of the ancillary equipment, such as firing system, furnace tending assembly, transport system, etc.

For new anode projects, Riedhammer now only offers open-top baking furnaces. “For the same anode quality it can be operated at faster fire cycle and thus has a higher output. In addition, emissions are lower because the combustion in the flue walls has been optimised in recent years,” explains Mr Janousch.

The market for new anode baking furnaces and the modernisation of existing plant has been somewhat depressed for quite some time as a result of the extremely low prices for primary aluminium. By contrast, 2011 was a markedly successful year for the Carbon Division.

In March 2011 Hindalco awarded Riedhammer a contract for the engineering of a new anode baking furnace with 34 sections, to be built at its smelter complex in Renukoot, India. The open-top furnace is designed with nine pits per section and an annual production of 140,000 tonnes of baked anodes. The engineering was completed in mid-2011 and
the civil works started at the end of last year. Refractory lining is scheduled to be completed in the fourth quarter of 2012, and commissioning will be early in 2013.

At Dubal, the refractory material of an existing baking furnace was replaced and the furnace relined; this meant replacing all of the flue walls and some of the headwalls. Prior to modernisation, the furnace had achieved a service life of 180 fire cycles without any of the flue walls being replaced. Dubal was obviously more than satisfied with the work carried out by Riedhammer because it honoured the company with an award for excellence in quality.

In addition, as mentioned above, Riedhammer carried out a conversion at Trimet in Hamburg; it also carried out the installation and commissioning for Kazakhstan Aluminium Smelter (KAS) in Pavlodar.

KAS is the only aluminium smelter in Kazakhstan, which lies in central Asia near the border to China. The electrolysis plant was built during the first phase in 2007, albeit without an anode plant at that time. The capacity of the smelter was doubled in the middle of 2010, to 250,000 tonnes a year.

For the KAS project, Riedhammer undertook the complete planning of the anode baking facility, supplied the whole plant and subsequently commissioned it. KAS was thus Riedhammer’s most comprehensive order to date for the complete installation of an anode baking facility. The order covered three partial contracts:

- 2008: the engineering package
- 2009/10: the supply of materials and equipment comprising refractories, firing system, two furnace tending assemblies, anode transport system with anode cleaning machine and the fume treatment plant
- 2011: the contract to install at site the material and equipment supplied and to commission the baking furnace facility.

“What was special about this project for us was that we acted as the general contractor. There was no EPCM contractor between us and the client as is often the case with large projects. Instead, we took on this role ourselves and processed the whole order working directly with the client,” emphasises Mr Janousch.

The scope of supply included the baking furnace (refractory material), the firing system, the fume treatment plant, the furnace tending assemblies and the anode handling system (conveyors and anode cleaning machine). “This was without doubt one of the most important projects Riedhammer had ever undertaken given its commercial significance and our objective of promoting and establishing open-top technology as well as supplying complete solutions,” adds Mr. Janousch.

The furnace has 50 sections, with seven pits per section. There are three fire groups with a fire cycle time of 23.5 hours. The unit is fuelled by heavy oil and has an annual production capacity of 150,000 tonnes of baked anodes.

Anode-baking furnace at KAS. The sections shown in the photo are filled with green anode that is covered by a layer of petroleum coke to prevent the anode burning.
The project was demanding given the climatic conditions prevailing in Kazakhstan: winters with ‘Siberian’ temperatures that can go down to -48 °C and summers where the thermometer can soar to 45 °C. Timing was therefore something that had to be kept in mind. Erection of the equipment started at the end of May 2011, and the firing system and furnace tending assembly were handed over to the client early in December, after which the furnace drying out began. Refractory lining of the furnace had been carried out between June and November 2011. The conveying system, second furnace tending assembly and the fume treatment plant were handed over in February 2012. Production started at the end of March, and the first baked anode was unloaded in April. The complete anode baking facility, engineered, delivered and built by Riedhammer, was handed over to the client in May 2012.

**Mode of operation of a baking furnace**

An open-type anode baking furnace like the one at KAS comprises 50 sections, each of which has seven pits enclosed within eight flue walls. The furnace is fired from the top via the flue walls and the flue gas transfers heat to the refractory material and the anodes. The anodes are baked to a temperature of about 1,100 °C.

The flue walls are meander-like. The exhaust gas is channelled through the flue walls via three baffles before being channelled via the headwall to the next flue wall. In this way, the whole volume of exhaust gases passes through all of the sections and heats up the baking furnace.

There is a partial vacuum in the system which drives the fumes towards the exhaust. At the outlet of the furnace, the flue gas has a temperature of 250-350 °C, it is then transferred to the fume treatment plant.

Depending on the production and the furnace construction, the fire is moved after 22-32 hours; at KAS the fire cycle time is 23.5 hours. A fire covers 16 sections: three sections in preheating, the burner bridges are positioned on three following sections (main fire), and six sections are being cooled. In this way, 12 sections are effectively standing in the heating flue. During this time, one section is being unloaded, two sections are empty, in order to carry out maintenance work (e.g. to sealing of expansion joints), and a further section is being loaded. At KAS, the baking furnace is equipped with 50 sections, two more than actually necessary, in order to allow the client more time for maintenance due to the fast fire cycle.

The performance of the baking furnace is tailored to the performance of the electrolysis plant. In addition, there is reserve capacity to compensate for any loss of anode production if the baking furnace has to undergo comprehensive maintenance, with refractory replacement, after seven or eight years.

“The flue wall is the heart of the furnace”

Producing a consistently good anode quality – with high energy efficiency and as high a
throughput as possible – is the be all and end all of a good baking furnace. The benchmarks for good anode quality that can be influenced by the baking furnace are the heating-up gradient, the final firing temperature, the soaking time and, particularly important, the temperature distribution in the baking furnace.

With regards to the heating-up gradient, it should be noted that an anode is susceptible to cracking at temperatures up to 600 °C as a result of degasification during the heating-up phase, and the resultant emission of pitch fume. According to Mr. Janousch: “If one chooses too high a heating-up gradient during this phase, there will be a deterioration in anode quality.”

In order to maintain a consistently good anode quality it is necessary to maintain a uniform temperature distribution in the sections. “The flue walls, into which the firing takes place, are the heart of the furnace. It is important here to have the proper partial vacuums. The flue walls have to be well designed in order to be able to regulate them properly. Basically, this is where the furnace builder’s special expertise comes to the fore,” he says.

The flue wall is also an important interface between the firing system and the furnace and it has to be specified precisely. “Because of problems associated with the interface, we recommend that our clients award a complete package, to a single contractor, preferably of course including the refractory materials, the refractory lining and the firing system. Then the client only has to deal with the interface to the fume treatment plant,” he explains.

The suppliers of the equipment are issued with the necessary specifications by Riedhammer: the anodes to be loaded into the baking furnace, the fire configuration and temperatures required, energy consumptions, quantities of exhaust gas, drawings of the dimensions specifying the battery limits, etc., in order to be able to design the equipment accordingly.

Anode baking is an energy intensive process so continually reducing the specific energy consumption as far as possible is more important today than ever before. Great progress has been made in this respect in the last ten or twenty years. Today, a modern anode baking furnace has an energy consumption of 1.8 GJ/tonne of baked anode. In the mid-1990s the figure was about 2.5 GJ/tonne, or over a third more.

A lot has also been done with respect to throughput times: whereas fire cycle times of 28-32 hours used to be typical, the value today is more like 22-26 hours because the heat transfer of modern furnaces is significantly better. “The flue wall is designed in such a way that there is uniform heat transfer and the soaking times are correspondingly shorter,” says Mr. Janousch. The magic word is Computational Fluid Dynamics (CFD). Thanks to computer-aided calculation and simulation of different flow distributions in the baking furnace, achieving an almost optimal design of flue wall is increasingly becoming reality. It used to only be possible to achieve what now takes place in advance by carrying out measurements after the furnace had been built.

Thanks to the optimised design, productivity has increased still further: whereas baking furnaces used to have a maximum of six or seven pits, modern units are now designed with up to nine or ten.

**Growth markets outside Europe**

A glance at Riedhammer’s reference list shows that Europe no longer plays a major role when it comes to the anode baking furnace business. Asia, the Gulf region and Russia are the places today where new capacity is being installed or modernisation is being carried out on a large scale. According to Mr. Janousch, there are also a number of plants in North America that will have to be modernised sooner or later. The same is true in South America, although in this region the necessary financial investment may be lacking in some cases.

This is a cyclical business and projects involving new plants are only implemented every once in a while. “Our strengths also lie in the modernisation of existing plants where the client does not want an off-the-peg product but a tailored solution. At the moment we are modernising a closed baking furnace at PT Inalum in Indonesia,” he says. This is a small 16-section furnace with one firing group. Riedhammer has already modernised baking furnaces at PT Inalum in 2008/09.

For future projects involving new plants, Janousch is aiming to act together with partners as a full-range supplier of anode plants in order to jointly design, engineer, procure, construct, commission and start-up anode plants, mainly comprising the following facilities:

- Recycled processing plant to treat green and baked scrap returned from the anode production facilities and anode butts from the smelters
- Green mill
- Anode-baking furnace and ancillary equipment
- Waste gas cleaning systems to treat the fumes from the green mill as well as from the baking furnaces
- Storage area for green anodes
- Area for cleaning and storage of baked anodes
- All equipment to transport and transfer the raw materials (calcined petroleum coke and coal tar pitch) from the port to the anode plant.

“The demand for high quality anodes today and the need to adapt to the requirements of a growing and dynamic aluminium market are the driving forces behind being able to offer complete solutions for modern anode plants. Our expertise and many years of experience worldwide are key factors that will allow us to prepare and submit proposals that are highly competitive both from the technical and an economical point of view,” says Mr. Janousch.