STEULER KCH

Refractory Systems | **FOCUS ON 4000 °F**

Focus on Progress

FOCUS ON 4000 °F

Dipl.-Ing. Jens Sperber*, Head of R&D and Application Technology
Dipl.-Ing. Daniela Schweez, R&D and Application Technology
STEULER-KCH, Refractory Systems Division

Increasing productivity and efficiency demands in the chemical and petrochemical industry require chemically high resistant refractory lining materials being able to withstand temperatures up to 2200 °C (4000 °F). These higher working temperatures are associated with modified physical properties of the lining material. Besides a high refractoriness of the lining material and its chemical resistance a significantly lowered creep behaviour is required for several applications.

The incineration of gaseous components in the chemical and petrochemical industry has been limited up to 1900 °C (3450 °F) as available refractory lining materials like mullite bonded corundum bricks or directly bonded corundum bricks didn´t allow higher working temperatures. Recent brick developments on the basis of partially stabilized zirconia permit considerably increased working temperatures up to 2200 °C (4000 °F).

In this paper customised lining concepts for high temperature processes up to 2200 °C are discussed. Based on more than 25 years of experience STEULER-KCH shows some examples of material for high temperature processes, especially regarding applications in chemical and petrochemical industry and the production process of carbon black.

Introduction

Steuler-KCH GmbH has been a successful supplier of ceramic products for the chemical and petrochemical industry. Tailor-made lining concepts are applied in thermal processing units like sulphur recovery units, POX- and carbon black reactors. On the next pages different types of materials for the application in gaseous processes are discussed. Besides the high grade standard brick types like Suprema ME 901 and Suprema KE 99 a newly developed high creep resistant material called Suprema KE 952 as well as new type based on partially stabilized zirconia are presented. In addition to this insulating materials based on hollow sphere corundum complete the portfolio.

High grade standard and creep resistant bricks

Mullite-bonded or direct-bonded corundum bricks have been successfully applied in most of the above described applications. Based on the possibility of adapting the formulation to the needs of the process there is a broad variety of material conception possible (Figure 1).

In general the portfolio can be divided in three different kinds of product groups: The first group covers mullite bricks exhibiting the lowest alumina content and to the same time the low-

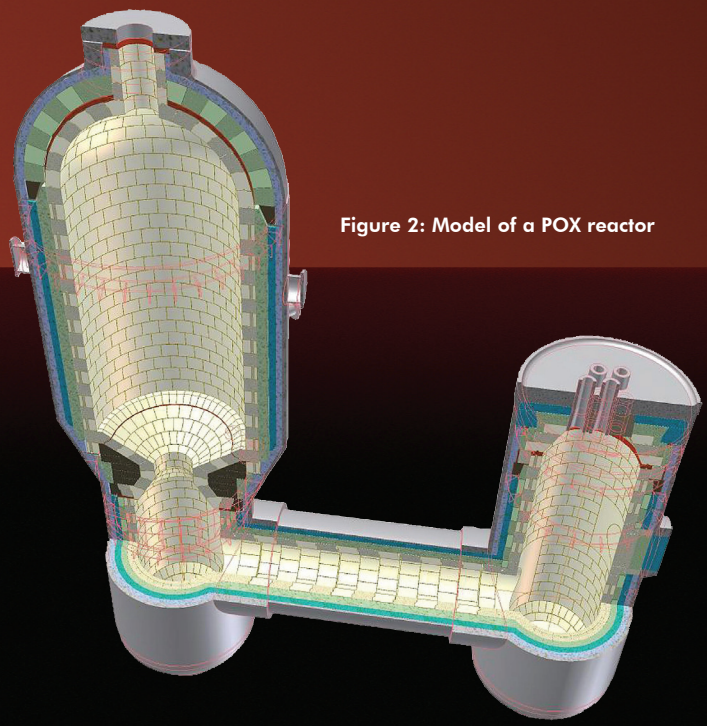

Figure 2: Model of a POX reactor

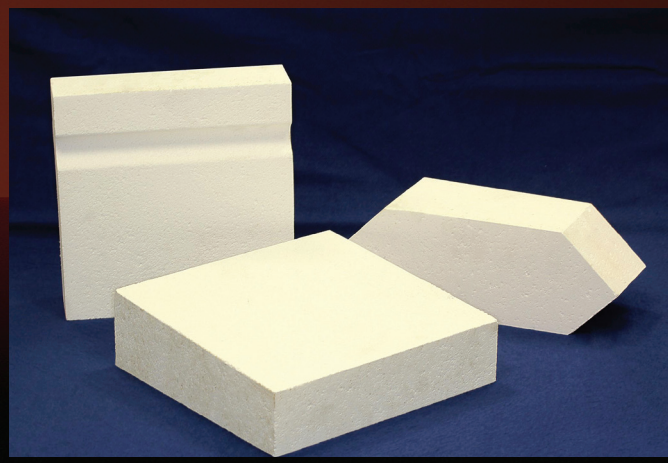

Figure 3: Examples of different hollow sphere corundum insulating bricks.

est creeping behaviour. The second group comprises mullite-corundum bricks with an enhanced thermal shock resistance compared to group one and three. The best thermal shock resistances exhibited the mullite-corundum bricks with alumina contents between 85 and 90 wt.-%. The third group is characterized by high alumina bricks with a maximum working temperature of 1900 °C. All of these products are made of fused raw material qualities to enhance the corrosion resistance properties. If a certain application requires a higher alumina content of app. 95 %, like in some sulphur recovery units, the thermal shock behaviour is slightly decreased. But on the other hand the creep resistance could be enhanced compared to a direct-bonded corundum brick.

Essential for the brick properties are well selected calcined aluminas for the bonding of the matrix. Especially the use of submicron aluminas can lead to enhanced properties of the bricks. A Typical application of high grade materials in a POX-reactor with hollow sphere corundum insulation layer is shown in (Figure 2).

Insulation materials based on hollow sphere corundum

In most of the described applications an insulation layer with nearly the same chemical and thermal properties as the hot face brick is needed. To achieve this aim the use of hollow sphere corundum as basic raw material is commonly practised.

Due to the existence of highly aggressive gases it may be necessary to use direct-bonded materials like Suprema KE 99 LW to reduce chemical reactions between the lining and the corrosive.

Table 1: Properties of different types of high grade standard and creep resistant materials (green).

	ME 751	ME 901	KE 99	KE 952	KE 992
Al_2O_3 SiO_2 Fe_2O_3	78 21 0.2	90 9 0.2	99,5 0,2 0.1	94 5 0.2	99,5 0,2 0,1
Bulk density in g/cm³	2.70	3.05	3.35	3.25	3,25
Apparent porosity in Vol.-%	15	15	15	14	17
Cold crushing strength in MPa	100	100	120	150	60
Young´s modulus in MPa	38,000	20,000	75,000	25,000	45,000
Linear thermal expansion (35-1000 °C) in %	0.5	0.6	0.5	0.72	0,85

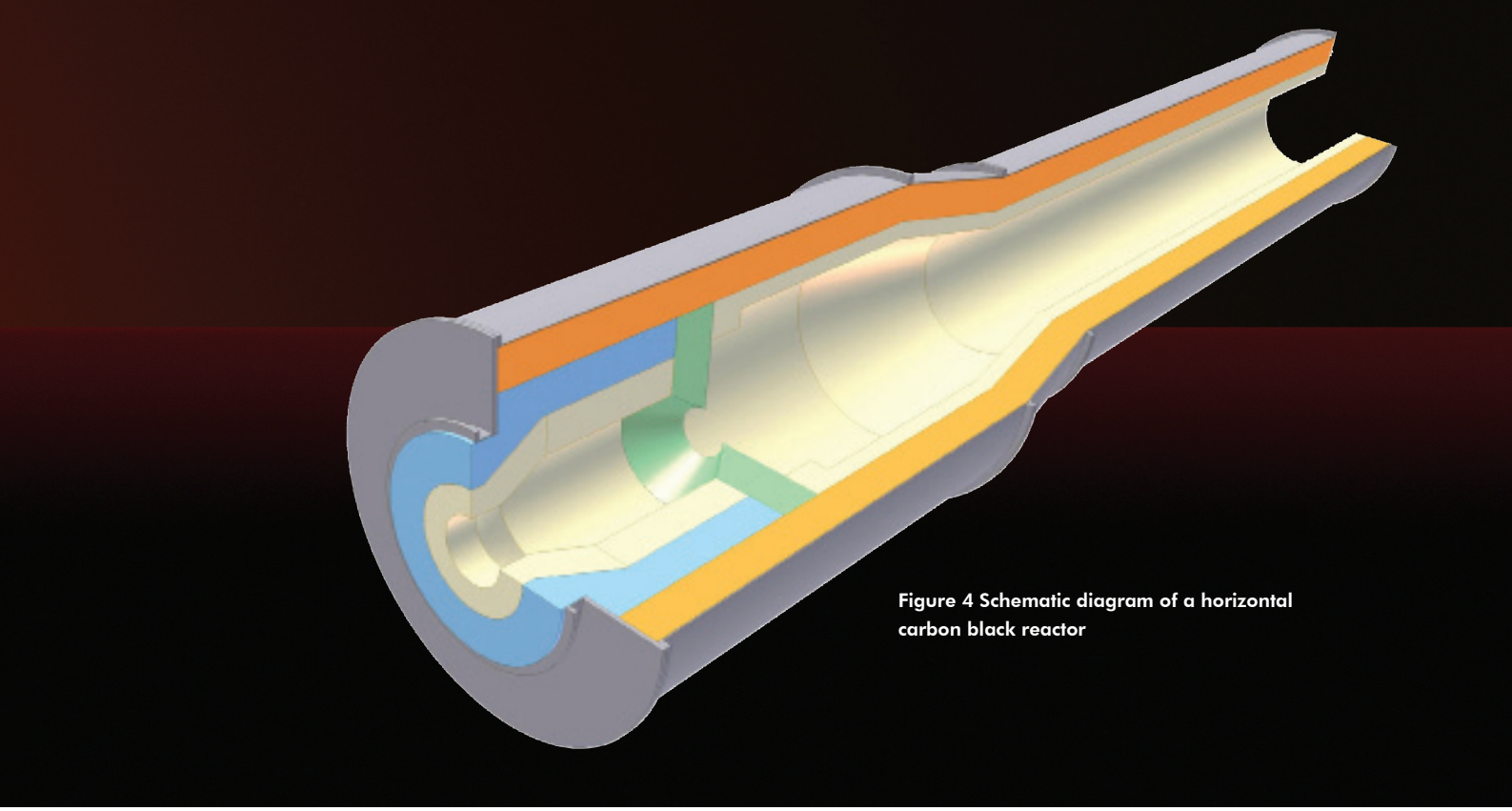

Figure 4 Schematic diagram of a horizontal carbon black reactor

The best performance in high temperature applications accompanied with the highest creep resistance showed a mullite-bonded version of the insulating brick called Suprema ME 90 LW. The creep rate of this brick shows values of Z < 0.5 % after 25 hours at 1600 °C with a load of 0.1 MPa. A small variety of shapes is shown in Figure 3.

High temperature materials based on partially stabilized zirconia

In some applications, e.g. carbon black reactors, the possible process temperatures has been limited due to the usually installed corundum or corundum/mullite lining material with a maximum working temperature of app. 1900 °C. The efficiency of this process depends on the obtainable temperature in the incineration chamber.

Bricks based on zirconia were evaluated as possible lining material for this application. Tests showed that this Ca-stabilized lining material can be applied up to 2200 °C (4000 °F). A fully stabilized zirconia raw material is not suitable as the thermal shock resistance is significantly reduced.

A partially stabilized raw material with a baddeleyite content of app. 40-60 weight-% exhibits enhanced thermal shock properties so that the lining of the incineration chamber of a carbon black reactor becomes possible. Even a further increase of the obtainable working temperature is imaginable by applying yttrium-stabilized zirconia raw material for temperatures up to 2500 °C (4500 °F). A typical configuration of a horizontal carbon black reactor is shown as schematic diagram in Figure 4.

Table 2: Properties of different types of insulating bricks based on hollow sphere corundum

	ME 90 LW	KE 95 LW	KE 99 LW
Al_2O_3 SiO_2 Fe_2O_3	86 13 0.2	93 5 0.2	99 0.7 0.2
Bulk density in g/cm³	1.50	1.50	1.55
Apparent porosity in Vol.-%	51	52	54
Cold crushing strength in MPa	15	15	14
Young´s modulus in MPa	5,000	5,000	5,000
Linear thermal expansion (35-1000 °C) in %	0.65	0.7	0.75

Figure 5: Side arch brick based on partially stabilized zirconia.

The table (Table 3) shows the chemical and physical properties of zirconia based brick materials. Additionally shown is the data of yttrium stabilized brick type with a further extended service temperature. Additionally this type of brick shows enhanced thermal shock behaviour of app. 40 %. Both material grades can be manufactured by dry pressing or dry ramming method with similar properties.

The generation of highly creep resistant materials can improve the lifetime in general caused by keeping the tensioning of the lining at a suitable range. For an extremely high temperature level zirconia bricks are an appropriate alternative to common used alumina based material. SUPREMA CZ 945 and SUPREMA YZ 927 are two of these kind of bricks which are able to sustain this temperature level.

Conclusions

At least there is a certain variety of lining material available depending on the process. In most of the applications an improvement of the lining could be possible. The necessity of a high communication level between customer and supplier to reap this profit is obligatory.

Table 3: Properties of different types of zirconia material for carbon black reactors

	CZ 945	**YZ 927**
ZrO_2	95	92
CaO	4	
Y_2O_3		7
Fe_2O_3	0.2	0.2
Bulk density in g/cm³	4.50	4.65
Apparent porosity in Vol.-%	23	21
Cold crushing strength in MPa	60	50
Young´s modulus in MPa	18,000	10,000
Linear thermal expansion (35-1000 °C) in %	0.75	

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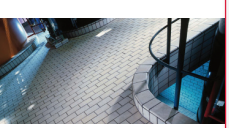

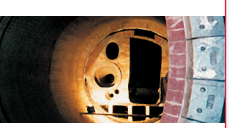

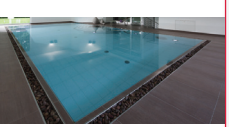

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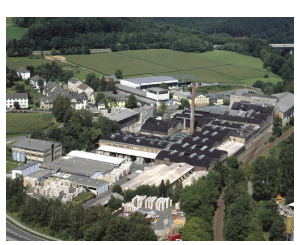

Höhr-Grenzhausen site

STEULER-KCH GmbH
Berggarten 1
56427 Siershahn | GERMANY
Phone: +49 2623 600-0
Fax: +49 2623 600-513
E-Mail: info@steuler-kch.de
www.steuler-kch.de

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