The cost and competitive pressure to improve the energy-efficiency of ceramic manufacturing processes is increasing. The potential for optimization is enormous. Within the ENITEC project, scientists and engineers are looking for technical solutions.

Construction engineers mainly select materials under aspects of functionality and costs. However, they increasingly take the CO\textsubscript{2} balance into account as industry pursues sustainability goals or requires eco-labels for its products. It is expected that the CO\textsubscript{2} balance will become an important competitive factor in the near future. Moreover, additional legal regulations or incentive systems will come into effect by means of which the German target of reducing CO\textsubscript{2} emissions by 40 % till 2020 and by 80 % till 2050 (as compared to 1990) is to be reached. Thus, energy efficiency is an important topic under marketing as well as politico-economic aspects.

The ceramic industry consumes 1.2 % of the primary energy in Germany, and thus belongs to one of the most energy-intensive branches. A main part of this energy is used for ceramic heat treatment processes. The energy efficiency of the heat treatment process is calculated from the ratio of theoretical consumption of primary energy in Germany (Source: AGEB, www.env-it.de).
retically required energy to used energy. For advanced ceramics, the energy is only 3 to 10%. Thus, there is a great potential for improvement.

Within the framework of the ENITEC joint project, where three ceramic manufacturers (CeramTec GmbH, Lapp Insulators GmbH, BCE Special Ceramics GmbH), two furnace manufacturers (Eisenmann Maschinenbau KG, FCT Systeme GmbH) and two research institutions (Fraunhofer ISC and IWM) are participating, methods are developed to reduce energy consumption during sintering of advanced ceramics. The project is funded by the Federal Ministry of Education and Research (BMWi) represented by the Project Management Agency Karlsruhe (PTKA).

Within the project, the scientists and engineers investigate heat treatment processes for continuous and batch furnaces as well as for oxide and non-oxide ceramics with component sizes ranging from millimeters to meters in order to get solutions that are relevant for the majority of advanced ceramics.

By reducing the energy consumption for heat treatment processes a conflict arises for many process parameters. If heating and cooling rates are increased, energy consumption – due to the shorter cycle time – is reduced but the reject rate might increase as, for example, temperature gradients lead to tensions and cracks inside the sintered bodies. Furthermore, too high heating rates result – due to temperature gradients – in warpage or non-uniform sintering in the fired stack. This results in an increase of energy consumption during finishing. An improved furnace insulation might also have disadvantages: the cycle times are often increased by slower cooling rates in batch furnaces. This does not only lead to higher energy costs for the production of furnace insulation but also to higher energy costs on account of the depreciation of the furnace.

In order to solve the conflict between energy reduction, high throughput, lower reject rates and near-net shape sintered bodies, computer simulations are essential. They help to determine the optimum process parameters by linking temperature distribution and energy balance of the furnace with material behavior. The relevant size scales range over three orders of magnitudes: from some meters in the furnace up to some millimeters in the component. For simulations, FE methods are suited which are linked via sub models.

In FE models, the material behavior can be precisely predicted using formal kinetic methods. One of these methods, the known kinetic field approach, is perfectly suited to precisely describe the debinding as well as sintering kinetics. The input data for model calculations are determined by thermooptical measurement methods (TOM). During debinding and sintering a very good reproducibility of the measurements has already been achieved. This is – measured by means of the mean standard deviation between the single measurement graphs along heat treatment – below 0.1% so that very exact predictions of the material behavior can be made. Additional input data for FE simulations such as high-temperature conductivity are measured using TOM. The interaction of computer simulations and high-temperature measurements might result in a significant reduction of the heat treatment process and energy consumption.

CONTACT
Dr. Friedrich Raether
Fraunhofer Center for High-Temperature Materials and Design HTL
friedrich.raether@isc.fraunhofer.de
FURNACE CONCEPTS FOR CARBON FIBER PRODUCTION

Many experts consider carbon fibers as the most important construction material of the 21st century. Their outstanding mechanical properties make them interesting for all applications where light materials are required that can also withstand mechanical and thermal loading. So, more cost-effective carbon fibers might replace step by step traditional construction materials such as steel or alumina. The excellent future prospects of carbon fibers induced Eisenmann Anlagenbau GmbH & Co. KG, as expert for thermal processing technology, to deal more intensively with this high-tech material and its production process. Today, the core competencies of the company include innovative furnace technologies for oxidation and carbonization as well as highly effective exhaust air purification systems with integrated energy recovery systems.

The conversion of the precursor material into a carbon fiber is performed in multiple thermal process steps with subsequent surface activation. In the first process step, the fiber is oxidized at temperatures from 180 to 280 °C for 60 to 120 minutes. The following carbonization process is usually performed in two stages (pyrolysis between 300 and 1800°C in an inert atmosphere). The carbonization process is followed by an electrolytic surface treatment and a sizing application. The further development of the market potential of carbon fibers will largely depend on the price trend. For this reason, cost savings along the entire process chain are required. As Eisenmann supplies oxidation and carbonization furnaces as well as exhaust air purification systems, which is unique on the market, the company is able to offer its customers optimally harmonized energy recovery systems, and thus to increase the efficiency of the whole system. The optimization of the furnace gate technology is another promising approach to reduce energy consumption. For this purpose, Eisenmann developed a new, patent pending air lock which offers significant advantages – such as e.g. best temperature distribution inside the furnace as well as minimum condensate formation – over commercially available gate systems.

ULTRA-LIGHT, EFFICIENT HIGH-TEMPERATURE INSULATING MATERIALS

In ceramic industry, insulating fire bricks (IFB) and high-temperature insulation products made of aluminum silicate wool (HTIW) are mainly used for high-temperature insulation. The Rath Group, a family-owned company in the fifth generation, offers its customers – according to the type of kiln – various concepts. The product range covers the entire refractory spectrum of monolithics, dense bricks, IFB and HTIW products.

In discontinuous industry kilns up to 1650°C, HTIW products are the best choice as they combine the advantages of low heat conductivity, low weight, heat storage and excellent temperature shock resistance. At operating temperatures of more than 1650°C vacuum formed shapes are particularly used in smaller furnaces. In comparison, IFB are used in larger furnaces. In continuous kilns operated at more than 1200°C, insulating fire bricks integrated in the walls are on a level with HTIW products in terms of heat conductivity and heat storage. Furthermore, they are more effective. With regard to the price/performance ratio they are even more cost-efficient if a more stable steel construction is necessary. At higher temperature ranges, HTIW modules in the furnace roof show better heat insulation as compared to IFB. Only at an operating temperature of more than 1650°C a complete lining of the furnace with IFB is necessary. Aside from technical and economic aspects, safety and health protection are important application and selection criteria.

The Rath Group with its headquarters in Vienna can look back on a 120-year company history. The company employs nearly 600 people worldwide and has production facilities in Austria, Germany, Hungary and the USA.
IMPORTANT DATES

AdvanCer training courses
“Advanced ceramic materials”
• Part 2: Machining
  May 9 and 10, 2012 (Berlin)
• Part 3: Construction, testing
  November 8 and 9, 2012 (Freiburg)

Seminars and workshops at Fraunhofer IKTS Dresden
• DKG seminar “Thermoplastic shaping of advanced ceramics – Technology and training”
  October 10/11, 2012
• DKG seminar “Debinding of ceramic bodies”
  October 11/12, 2012

For further information please see www.advancer.fraunhofer.de

NEWS

BRIDGE BUILDING AWARD TO PROFESSOR ALEXANDER MICHAELIS

Prof. Alexander Michaelis, director of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS, was awarded the ACerS Bridge Building Award at the 36th International Conference and Exposition on Advanced Ceramics and Composites in Daytona Beach at the end of January. The Bridge Building Award, which is annually awarded by the American Ceramic Society, recognizes individuals who have made outstanding contributions to engineering ceramics and thus significantly contributed to the visibility of the field and international advocacy. The award, in particular, recognizes the contribution of Prof. Michaelis in the field of energy and environmental technology.

FRAUNHOFER CENTER FOR HIGH-TEMPERATURE MATERIALS AND DESIGN FOUNDED

At the beginning of 2012, the Fraunhofer Center for High-Temperature Materials and Design HTL was founded. Fraunhofer HTL comprises the ceramic competencies of Fraunhofer ISC at the sites in Bayreuth and Würzburg and develops high-temperature components for energy, propulsion and heat technology. One focus is on the improvement of energy efficiency in industrial heat treatment processes. As 10% of the primary energy in Germany is used for industrial heat treatment processes, there is an enormous potential for improvement. Various research fields of HTL deal with energy efficiency: CMC structures for gas turbines, ceramic fiber development for high-temperature insulations, design of kiln furniture and heat exchangers, ceramic reinforcement of metal pressure vessels as well as optimization of heat treatment processes. Fraunhofer HTL has three working groups (CMC Structures, Polymer Ceramics and High-Temperature Design) with 30 employees. On more than 2400 square meters of usable floor space at both locations various well-equipped laboratories and pilot plants are available for development projects and R&D services. www.htl.fraunhofer.de

CMCEE AND CERAMITEC

From May 20 to 23, 2012, the CMCEE conference will take place for the first time in Dresden. Under the topic “Ceramic Components and Materials for Energy and Environmental Technology” experts discuss and identify current and future trends in the field of advanced ceramics. On May 24, the conference is continued as “Day of Technical Ceramics” at the CERAMITEC fair in Munich. Numerous conference participants are expected to visit the fair and to be available as speaker and discussion partner. At the joint stand of TASK GmbH (B6, 313/418) Fraunhofer IKTS, ISC and IWM present their latest developments. Highlights include battery storage systems, ceramic components for automobile engineering and ceramic membranes for liquid filtration, pervaporation, vapor permeation and gas separation.

EDITORIAL NOTES

A publication of:
Fraunhofer Demonstration Center AdvanCer
Winterbergstrasse 28, 01277 Dresden, Germany
Phone +49 351 2553-7504
advancer@ikts.fraunhofer.de
www.advancer.fraunhofer.de

Editors: Susanne Freund, Andrea Gaal

All rights reserved. Reprints permitted only upon express authorization by Fraunhofer Demonstration Center AdvanCer. Photo credits on request.