Optimization of the thermal production process

Friedrich Raether Is director at Fraunhofer-Center for High Temperature Materials and Design HTL. With heat processing he speaks about trends and developments for the thermal production process as well as Industrial kiln construction.

Could you please give a brief overview of your institutes´ most important research focuses?

Raether: Fraunhofer-Center for High Temperature Materials and Design HTL bundles the ceramics activities of Fraunhofer-Institute for Silicate Research ISC. It currently has around 100 employees at its three locations in Bayreuth, Würzburg and Münchberg. More than 3,700 m^2 of high-quality laboratory and pilot plant space with state-of-the-art equipment is available for development projects and R&D services.

The parameters of heat treatment processes are optimized for energy efficiency and productivity for manufacturers of ceramic and metal components. New and lightweight materials are developed together with manufacturers: Ceramics and powder metals as well as refractory materials. For manufacturers of thermoprocessing technology, high-temperature components are designed and built as prototypes. Ceramic Matrix Composites (CMC) are developed in a closed process chain from component design and material design to production on a pilot plant scale. Mechanical as well as non-destructive and high-temperature material testing is offered as a service for industrial customers.

Which goals do you pursuit in these matters?

We design energy-efficient heating processes and thus contribute to the sustainable technological progress of society. For that, we develop high-temperature materials, high-temperature components, and high-temperature measuring methods. The HTL develops efficient new experimental and computational methods and uses them for its R&D and the optimization of thermal production processes. The primary goal is the implementation of research results in the industry.

What is the advantage of heat-resistant, lightweight materials for high-temperature technologies?

First of all, the lower heat capacity of lightweight components decreases energy consumption during heating. In many ceramic heating processes, kiln furniture contributes significantly to the weight of the furnace loading. Therefore, large savings can be obtained by using materials with a lower density and special load-bearing structures. Moreover, lightweight components gain or lose heat faster and thereby enable shorter thermal cycles, which increases both throughput and energy efficiency. The lower heat capacity leads to a faster heat distribution in the stack. This decreases temperature gradients and improves product quality. Usually, lightweight components also have better resistance to thermal shock, thereby increasing service life and reducing its CO_2 footprint.

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- **2012 to date** Director at Fraunhofer-Center for High Temperature Materials and Design HTL

Fraunhofer-Center for High Temperature Materials and Design HTL in Bayreuth, Germany (Copyright: HTL)

Which new horizons for additive manufacturing of ceramics would you stipulate?

Additive manufacturing (AM) of ceramic components requires two-step processes, where forming is done by 3D printers and heat treatment takes place in customary furnaces. The implementation of AM in the production of ceramic components is stimulated by several parameters:

- Better integration of all process steps, starting from component design, via additive forming, transfer of parts to the furnaces, debinding, sintering, and finishing up to final inspection.
- High degree of automatization at all interfaces.
- Better process monitoring by the integration of sensors in the control of the printing process.
- Better utilization of the design opportunities, which are offered by AM including computational methods for topology optimization and special education of construction engineers.
- Decrease in prices for AM equipment and feedstocks.

"For many processes, industrial kilns need higher flexibility."

Could you name some clean and green opportunities for industrial kiln constructions as well as their benefits?

For many processes, industrial kilns need higher flexibility. On the one hand, the load will vary due to volatile market needs, and kilns should be able to handle varying loads with optimal efficiency. On the other hand, energy availability will vary due to fluctuating output from regenerative energy sources. Flexible kilns should provide demand-side management on a time scale between some minutes and some days. Thermal management within the kilns can be improved using multilayer insulations with low-emissivity surfaces and hot gas fans for better control of gas flows. The CO_2 footprint of all wear parts – especially refractories - should be improved by increasing their lifetime and their recycling rate.

Is using hydrogen in ceramic industry kilns a topic for the future?

Yes, it already is a topic now since the planning and implementation of kilns take many years. Often, the transformation of gas-fired processes to electrically heated processes causes serious problems regarding heat distribution within the charge. Large furnaces further on rely on good heat transfer provided by industrial burners. Instead of natural gas, an increasing amount of biogas and synthetic fuels will be used for combustion. Hydrogen is a very promising clean fuel for ceramic furnaces if it can be produced and distributed in sufficient quantities. It can be mixed with other fuels in varying quantities, and it can be stored and transported in other molecular compositions like NH_3.

What about recycling as a sustainable option for a circular economy?

There are some ceramic products, where recycling is possible. E.g. with refractories, requirements regarding strength are rather low and composition is heterogeneous. Both favors recycling. Although the separation of different material types within the waste flow is still a challenge, the fraction of secondary refractory material will increase. In addition, other waste products like rice husk ash can be used for refractory production. However, for most ceramics, the quality of material recycled with current technologies significantly deteriorates, due to impurities and improper particle size. Research towards innovative recycling methods will be necessary to improve this situation. In the meantime, it appears as a more promising strategy to increase material efficiency by lightweight construction, modular design of ceramic components, and development of repair methods.

What other relevant topics for the industry do you see in the future?

Looking at regulations and taxes, which are already active respectively planned in the next years to achieve the sustainability goals of the German government and the European Commission, there is a tendency to relocate energy-intensive production in regions with lower standards. This would be counterproductive in terms of overall emissions and the resilience of the European economy. More political and technical effort is required to find sustainable and economical solutions for the future production of ceramics in central Europe.

Thank you very much for the interview!