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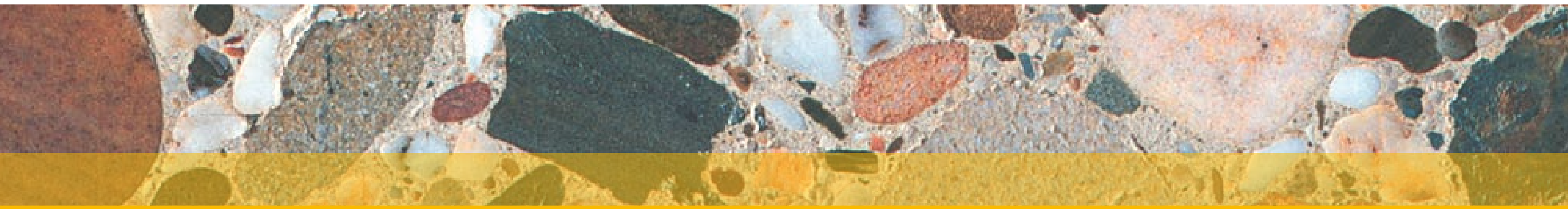
european cement research academy



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NEWSLETTER

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Burners for advanced alternative fuel usage

State-of-the-art technology for the utilisation of multifarious alternative fuels in ro-tary kiln firing systems

The trend of using more and more alternative fuels in cement kilns is a challenge for all kiln operators. A fast development in burner technology has been taking place with respect to the firing of multiple fuels with different combustion characteristics. A new burner generation fulfils the requirements of clinker processing with regard to these fuels. Alternative fuel co-processing can change the flame shape and temperature profiles in rotary kilns. Current knowledge and experience should be used to avoid negative impact on the clinker burning process and clinker quality as well as the kiln operation. New or modified rotary kiln burners allow to compensate adverse effects of alternative fuels through wide-range adapting capabilities of burner settings and may contribute to increasing the utilisation of alternative fuels.

In clinker production a suitable and high efficient heat transfer from flame to kiln feed was achieved with the establishment of rotary kiln systems for cement clinker production.

Development of burner technology

Based on rotary kiln technology burners were developed for the necessary heat transfer from respective fuels to the clinker burning process. With the technical evolution of rotary kiln burners some significant changes took place due to their adaptation to respective fuel properties. Particularly during the last decades an intensive development in burner technologies was achieved. **Fig. 1** displays the development of burners regarding respective fuels.

The development of burners was also driven by the evolution of environmental legislation. Nitrogen oxides emission rates have massively been reduced in the whole of Europe. Burner suppliers adapted to this amendment of the environmental legislation with new products such as the LowNO$_x$ burner. The low primary air rate is characteristic of this burner type. It is often lower than 10 % and results in reduced nitrogen oxides formation in the rotary kiln flame.

In the mid 1980s alternative fuel utilisation began, initially in calciner lines, and today almost 100 % alternative fuel firing in the precalciner has been achieved in some cases. A trend towards solid fuels is currently taking place which are increasingly also fed via the rotary kiln burner into the sintering zone.

Characteristics of alternative fuels

Alternative fuels for rotary kiln firing systems are mainly animal residues, waste oil, solvents, and lumpy materials. The lumpy materials are solid recovered fuels retrieved from industry and commerce as well as from municipal waste. These refuse derived fuels are the conditioned light fraction gained by air separation. The lumpy materials consist of shredded paper and paper board, plastics and foils, textiles and rubber and may contain metallic and mineral impurities. **Fig. 2** shows the compounds variety of these solid recovered fuels, which are also known as fluff, from waste.

The higher the substitution ratio of alternative fuels in the kiln firing systems and particularly with increasing the utilisation of solid lumpy materials, the more difficult flame control becomes. Contrary to other solid fuels like animal meal and sewage sludge, which are homogeneous and have suitable specific surfaces, or liquid and gaseous fuels, the fluff is characterised by

- substantial heterogeneity,
- high humidity,
- low specific surface, and
- considerable substantial distribution of physical and chemical properties affecting combustion.

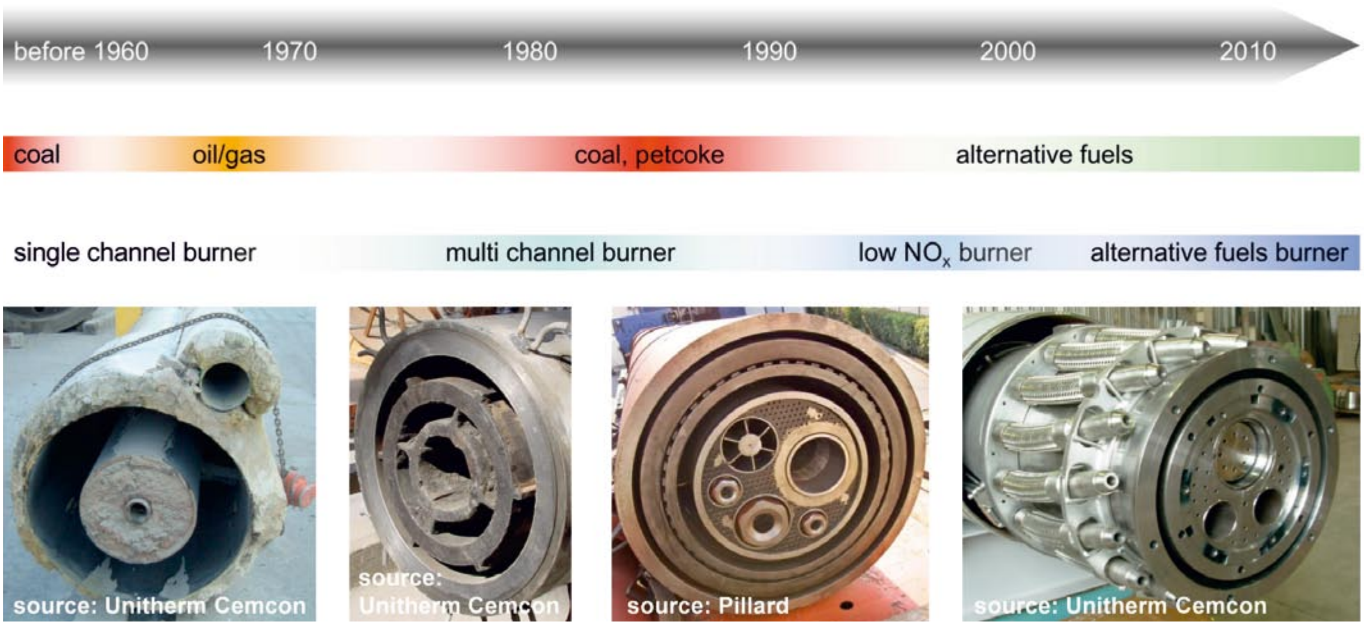
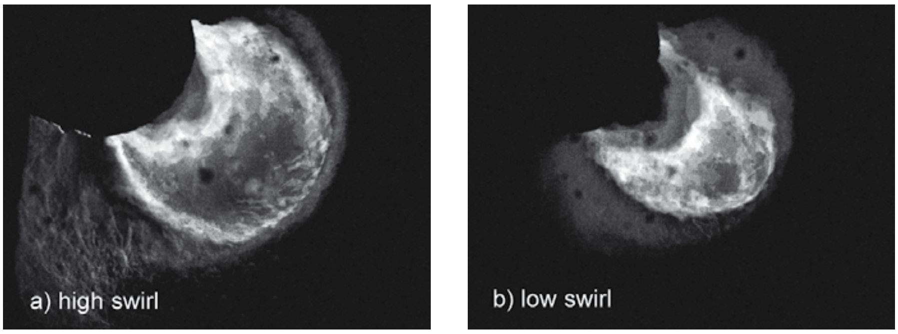


Fig. 1: Burner technology and its development

Source: VDZ

Fig. 2: Compounds of solid recovered fuels from waste.



Source: VDZ

Fig. 3: Thermographic pictures of a) a short expanded, highly swirled and b) a long, slim, slightly swirled flame.

Setting up an optimal flame for co-processing these fuels is challenging considering the various particle size distributions and the different ignition temperatures combined with the fluctuating moisture content.

Increasing prices for fossil-based fuels have brought economic benefits for the cement industry in the recent past. Some alternative fuels contain biogenic compounds. With regard to the implemented European trade system for carbon dioxide emissions in 2005 cement works operators are increasingly interested in co-processing such fuels because of their low carbon dioxide emission factors.

State-of-the-art technology of multi-fuel burners

The co-processing of alternative fuels in the rotary kiln firing system requires especially designed rotary kiln burners for a high usage of alternative fuels. Modern rotary kiln burners consist of multiple channels and pipes and enable the firing of various fuels and different fuel mixtures. These multi-channel and multi-fuel burners are characterised by a plurality of nozzles, tubes and annular channels facilitating the flexibility of incinerating ground and coarse solid fuels as well as liquids, pasty and gaseous fuels. The intensity of heat supplied by the fuels and the temperature profile in the rotary kiln are influenced both by combustion performance of the fuels, e. g. their physical and chemical properties, as mentioned above, and by the setting of the rotary kiln burner. A flame and combustion control is feasible by just regulating the primary air.

Flame geometry, swirl and temperature distribution as well as fuel combustion can be controlled by the geometry of the outflow system and by volume flows and velocities of primary air streams at the burner's tip. **Fig. 3** shows thermographic pictures of a high and low swirled flame by changing the geometry of the outflow system. The temperatures are illustrated in grey-scale colour-coded form.

Prospects for advanced alternative fuel co-processing

Alternative fuel utilisation in cement clinker production is still in progress and an ambitious challenge for plant operators and burner suppliers. The cement industry has to face various topics in alternative fuel co-processing. Shortening the plum of fuels, in particular of lumpy materials, suits the needs of an appropriate temperature profile in rotary kilns for the clinker burning process, the burnout of fuels and environmental issues. Finding an ideal burner position enhances the clinker burning process and clinker quality. Oxygen enrichment of primary or secondary air proves to be promising with regard to advanced alternative fuels combustion.

ECRA's CCS project stays on track and starts its next phase

A large project consortium is established to fund the upcoming research tasks

To limit the environmental impacts of the greenhouse effect, CO_2 reduction measures have to be applied in energy intensive industry sectors including the cement industry. Therefore, the International Energy Agency (IEA) and the World Business Council for Sustainable Development (WBCSD) developed a specific technology roadmap for the cement industry, in which Carbon Capture and Storage (CCS) plays a predominant role in order to achieve politically postulated targets. The European Cement Research Academy (ECRA) is investigating the technical and economic feasibility of CCS application in the cement production process.

ECRA contributed significantly to the IEA roadmap via the elaboration of 38 so-called technology papers which describe existing and potential technologies and their capacities to reduce CO_2 emissions. Also the major constraints have been stressed, especially with respect to carbon capture.

According to the IEA, the cement industry could reduce its CO_2 emissions by 18 % by 2050, compared with 2005 levels. The highest percentage of this reduction effort is attributed to the application of CCS (carbon capture and storage) technologies. The IEA vision for 2050 is that 450–500 cement kilns will be equipped with CCS technologies.

The ECRA CCS Project

The ECRA CCS project was started in 2007 and pursues a step-by-step ap-

Fig.1: The Steering Committee of Phase III of the ECRA CCS Project pictured at its first meeting in February 2010.

proach towards CCS with five phases. After each phase, the associated Steering Committee constitutes if the project should be continued or not.

Accordingly, in autumn 2009 the ECRA board decided to continue the CCS Project with the designated next step. Phase III envisages more detailed research on oxy-fuel and post-combustion technologies including also laboratory and small-scale trials with both reduction technologies. The research work for phase III is scheduled for 2010–2011.

Phase III of the CCS Project

At the beginning of phase III a project consortium was established which consists of cement companies, cement associations, equipment suppliers and a gas producer. The total budget for phase III is about 1.4 Mio. €. The first meeting of the Steering Committee was carried out in February (**Fig. 1**). The main issue was to agree on the research agenda for the next two years.

Both the research on oxy-fuel combustion and the research on post-combustion technologies is divided into several work packages. For each work package a smaller subgroup has been assigned which is involved in all its respective organisational issues. Some of the research tasks can be conducted by the Research Institute of the Cement Industry whereas other work packages have to be carried out by external subcontractors.

ECRA has therefore distributed "Calls for Tender" to selected companies and organisations likely to have the expertise for the required research. After having received all offers, the nominated subgroups will make a recommendation about the favoured subcontractor to the Steering Committee, which will make the final selection.

Research activities on oxy-fuel

The research regarding oxy-fuel combustion consists of six work packages. The ongoing work on modelling of the oxy-fuel process will be continued by the Research Institute. It will also investigate the impact of oxy-fuel operation on the clinker forming reactions

In contrast to this, the development of a new oxy-fuel burner requires advanced knowledge of specialist companies and is therefore put out to tender. Potential impacts on the refractories shall also be investigated by an external project partner. Before the gas stream can be transported and stored, an additional flue gas treatment has to be applied. A concept about the required measures shall be developed by a subcontractor here also.

Already within the framework of phase II it emerged that the application of oxy-fuel technologies would require significant changes of the process technology. A detailed development of the overall plant layout is the subject of other work packages. One important issue is to reduce air-inleaks. To achieve this, improved sealings have to be developed. This research task shall be assigned to an external subcontractor. Furthermore, the general design of a so-called two-stage clinker cooler has to be developed. The first stage is to be operated with a CO_2/O_2 gas mixture, the second one with air.

Post-Combustion Technologies

The research on post-combustion capture comprises four work packages. The activities regarding modelling of the post-combustion process will be continued by the Research Institute and laboratory trials regarding the absorbent degradation shall also be started. Another work package foresees small-scale trials in a cement plant. In this case the ECRA Steering Committee decided to cooperate with a post-combustion project which is planned at the Norwegian cement plant in Brevik.

The objective of the Brevik project is to install a test site at the cement plant where different technology providers can install their test rigs for post-combustion capture. Significant funding of the Norwegian Government is expected for this research project. The application will be filed by a Norwegian project partner. ECRA will fund the application and – in return – will be included without financial contribution in the next phases of the Brevik project.

Furthermore a FEED study about the installation of post-combustion technologies shall be conducted in 2011.

Further proceedings

International organisations like the IEA, GCCSI (Global CCS Institute) and also the EU have set ambitious goals for the cement industry to contribute to the required CO_2 reduction rates. Despite the very high costs, the application of CCS technologies seems to be an indispensible part of the overall reduction scenarios. If at all, for pilot and demonstration projects, international cooperation is essential.

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