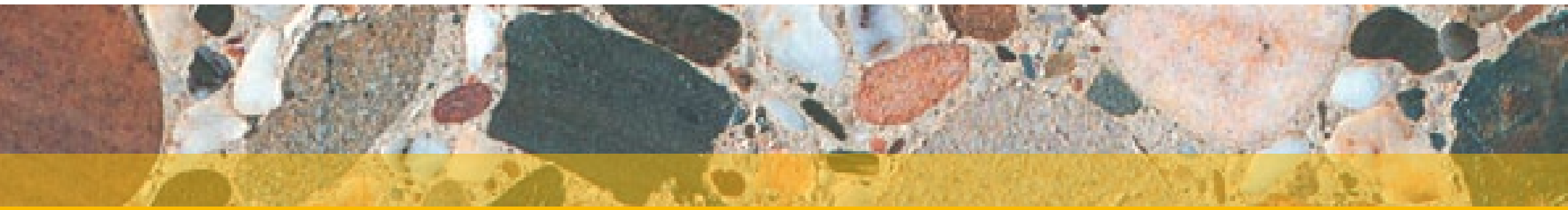
ecra

european cement research academy



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NEWSLETTER

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ecra events

- ecra General Assembly
  in Prague, 15 May 2008
- ecra Conference
  in Prague, 16 May 2008

Refractory materials in modern cement rotary kilns

Material choice, installation technique and condition analysis are decisive for the reliability of a cement kiln

The service life of refractory materials is an important cost factor in the clinker burning process. The lifetime of the refractory lining is dependent on a multitude of factors and above all on local stresses due to mechanical, thermal and chemical attack. In accordance with the local stresses suitable materials and types of lining are to be selected. Besides the suitable choice of the materials the proper installation of the refractory affects the lifetime of the lining. To prevent damage during operation the condition of used refractory material must be assessed correctly during maintenance.

The service life of refractory material depends on a number of influencing factors, which chiefly include the mechanical, thermal and chemical stresses prevailing at the site. Excessive mechanical stress can result in pop-outs, detachment (**Fig. 1**), concentric cracking, spiral torsion of individual brick tyres, breakouts in the tyre area, or axial grooves. This is usually attributable to the quality of the lining (executed too loosely or too tightly) or to excessive kiln out-of-roundness. Thermal overheating due to the absence of coating or direct contact with the flame can lead to melting symptoms, melted mass infiltration or recrystallisation, which in turn attenuates the brick structure. Temperature shocks, which may for example be caused by varying coating conditions or excessively fast warm-up, can lead to pop-outs. Chemical wear due to alkali infiltration, chromium ore corrosion or temporarily reduced atmosphere results in cracking and shattering of the structure. In this case, the choice of brick types should be reconsidered.

Selection criteria

The factors to be taken into account when selecting the quality of refractory materials for different kiln sections include the conditions of use, the coating behaviour of the kiln feed, the intensity of recirculating material systems, and the planned service life. The kiln inlet area is usually lined with spinel or chamotte bricks having an Al_2O_3 content > 40 %. The other bricks used are made of spinel or magnesite in the transition zone, of hercynite, magnesite, spinel or dolomite in the sintering zone and of high alumina or spinel in the kiln outlet area. In some cases, the inlet cone and the outlet are also lined with cast compounds.

Appropriate installation of the refractory lining allows the reduction of some mechanical stresses and thus rules out premature wear. The provision of adequate clearance between expansion joints and the reduction of kiln shell out-of-roundness during the laying of refractory bricks are of paramount importance. The kiln design has effects on the wear of the refractory materials. Two-support rotary kilns have a lower refractory consumption than three-support rotary kilns since they are subject to less mechanical stress. Another aspect which is important for the mechanical stress of the refractory material and thus for its wear is the attachment for the kiln tyre. Geared kiln tyres are obviously more advantageous than loose kiln tyres.

Outside the kiln, various refractory lining structures are chosen. Elements subject to higher corrosion include the bottom cyclone ceilings (**Fig. 2**), support flanges, suspended roofs in the front part of grate coolers, and the refractory sheath of burners. Different designs are chosen depending on the respective element.

Condition monitoring

To ensure high operational reliability of the kilns and plan kiln repairs, information on the condition of the refractory material is indispensable. Routine control of the kiln shell temperature by recording infrared radiation is a measure suited for surveying the condition from outside. Highly efficient automated recording and evaluation systems serving this purpose are available in the market. Evaluation of the maximum, mean and minimum kiln shell temperature allows statements to be made on lining and coating conditions. Further development can be estimated on the basis of the rate of temperature change.

Fig. 1: Lining detached due to insufficient clearance between expansion joints

Fig. 2: Cyclone ceiling segment fallen out

During a kiln stop, the thickness of the remaining bricks can be determined either by non-destructive testing or by drilling or breaking out windows. Experience shows that non-destructive measuring equipment does not furnish reliable measuring signals. Drilling with a rock drill (8 to 10 mm) allows determination of the precise thickness of the remaining bricks, but damaged bricks (cracking, alkali infiltration) cannot be detected. At critical points, the condition of the refractory material should therefore be examined by means of core drilling or breaking out windows. The drill cores and bare bricks thus obtained allow the condition to be assessed exactly. This method does, however, not allow the brickwork to be closed again durably when the remaining brick height is low.

Work on the refractory materials is one of the potentially most dangerous jobs in cement works. For that reason, employees should be instructed prior to beginning work on refractory material and informed of the specific risks inherent in this kind of work. Work performed in the rotary kiln and in the preheater requires different precautions with regard to safety at work. While safety precautions during coating removal and breakout as well as securing of the travel way constitute the principal measures in the rotary kiln, coating removal and questions relating to the erection of platforms, scaffolds and protective cover play a decisive role in the preheater.

The structural elements outside the rotary kiln that are exposed to the most severe stresses include the ceilings of the lower cyclones. The anchoring systems in particular are subject to severe corrosion symptoms. For that reason, anchorage frequently consists of a combination of ceramic and steel anchors. Inspection openings should be provided in the cyclone ceilings to allow the state of cyclone ceilings and the anchoring system to be scrutinised. Prior to installing the refractory lining in the preheater, the condition of the cyclone ceiling must be inspected from outside. When material coating is removed from the cyclone ceiling, it must always be chiselled off downwards through the control openings. Only upon inspection of the cyclone ceilings through the control openings can the refractory material of the cyclone be scrutinised from inside by means of travelling scaffolds. The scaffolds and working platforms can be installed when the go-ahead is given. For the sake of hazard prevention in case of simultaneous work at different points, the cyclones should be partitioned by means of needle gates.

The use of blended cements in concrete construction

Cements with several main constituents as sustainable solutions for concrete construction

On the basis of regionally available raw materials highly efficient cements were produced in Europe at all times in order to grant a safe concrete construction. Thus, the use of cements with several main constituents (blended cements) looks back to a long and successful tradition. Nowadays, in Europe far more CEM II cements are used than CEM I cements. However, regional differences do exist. ecra serves in this context as a forum for an exchange of experiences regarding the state of technology as well as prospects for cements which today cannot be considered to be "traditional" and "well tried".

44 participants from 21 countries attended the ecra seminar "Blended Cements" at Aalborg, Denmark and emphasized the importance of cements with several main constituents for the cement industry. Apart from the efficiency of various cement main constituents such as granulated blastfurnace slag, limestone and fly ash for the workability characteristics and the strength-forming capacity of cement-bound building materials, focus was put on the interaction of cement and admixtures and the durability of concrete. In this respect also the regional differences of cement application became clear.

Application rules

CEN/TC 104/SC1 "Concrete" prepared a synopsis of the national application documents to the European concrete standard EN 206-1 which shows that there are to some extent considerable differences regarding the cement application. In addition to the traditional differences in market conditions and construction practice, this also reflects the philosophies underlying the imposition of rules. Insofar, there are no regulations governing the application of all 27 basic cement types mentioned in EN 197-1, but regulations on the application of only a few cement types, which traditionally play a role on the respective national market. While comparing the application rules for cement differences concerning the requirements of the concrete composition have to be observed as well. For example, in some countries there are neither limitations regarding the maximum w/c ratio nor are there limitations regarding the minimum cement content for interior components. In various member states a combination of exposure classes XC4 and XF1 is attributed to external components. Requirements regarding the minimum compressive strength vary between "no requirement" and C32/40. The maximum w/c ratio is 0.60 to 0.50. The minimum cement content is between 150 and 320 kg/m³ (**Table 1**).

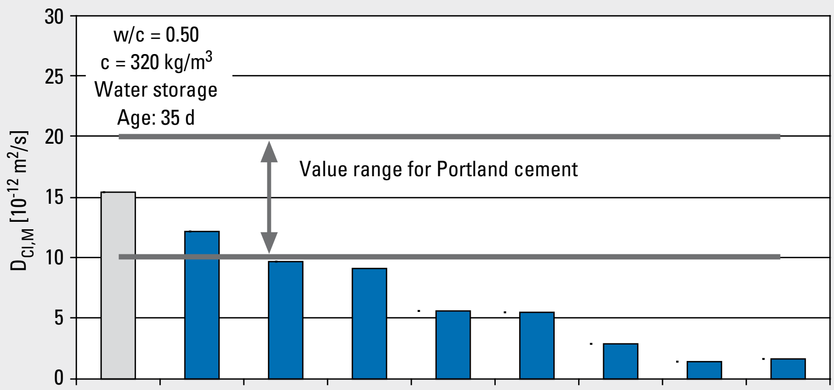
New cements

The requirements regarding the saving of resources, the reduction of energy use and the protection of global climate are considerable challenges which have to be taken up by all industries. As the afore-mentioned requirements have a considerable impact on the cement industry, which is one of the energy-intensive sectors of industry, the cement manufacturers have taken up this challenge by steadily optimizing their manufacturing processes with regard to the input of raw material and energy in past years. As a consequence, the cement manufacturers produce high-quality and efficient cements which enable their customers to produce

Country	max. (w/c)$_{eq}$	min. c kg/m³	CEM I	CEM II						CEM III		CEM IV		CEM V	
				S		LL		M							
				A	B	A	B	A	B	A	B	A	B	A	B
Austria	0.55	300	x	x	x				(x)	x	(x)				
Belgium	0.55	300	x	x	x	x	x	x	x	x	x			(x)	
Denmark	0.55	150	(x)			(x)									
Finland	0.60	270	x	x	x	x		x		x	x				
Germany	0.60	280	x	x	x	x	❍	(x)	(x)	x	x	❍	(x)	(x)	(x)
Ireland	0.60	300	x												
Italy	0.50	320	x	x	x	x	x	x	x	x	x	x	x	x	x
Netherlands	0.55	300	x	x	x	(x)	(x)	(x)	(x)	x	x	(x)	(x)	(x)	(x)
Norway	0.60	250	x	x		x									
Switzerland	0.50	300	x	x		x		(x)		x	x				
Great Britain	0.60	280	x	x	x	x				x	x	(x)	(x)		

x	permitted		not mentioned
(x)	with restrictions	❍	not permitted

Table 1: Comparison of application for cements in the framework of national application documents to the European Standard EN 206-1 by example of an external concrete component



Cement No	1	2	3	4	5	6	7	8	9
[mass %] Clinker	100	65	65	65	65	50	50	30	30
[mass %] Slag	–	5	10	15	35	30	30	50	50
[mass %] Limestone	–	30	25	20	–	20	20	20	20
f_{cm} [MPa]	56.7	53.4	49.6	50.8	57.0	54.0	58.1	45.2	44.8

Fig. 1: Chloride migration coefficient $D_{Cl,M}$ of concrete with w/c = 0.50 and c = 320 kg/m³ dependent on the cement composition – Water storage

efficient and sustainable concrete as well as concrete products with the respective specific constituent materials. The requirement to follow this path consistently raises the question of new cement types for the European cement standard EN 197-1. Currently cements which consist of 30-64 % Portland cement clinker, 30-50 % granulated blastfurnace slag and 6-20 % limestone seem to be of much interest. Up to now such cements are not included in EN 197-1. On the basis of investigations carried out by different laboratories certain experiences with such cements have already been gained. As indicated in **fig. 1**, due to the slag content these cements have particular advantages concerning the resistance against chloride migration (cements 6 to 9 in fig. 1). Limitations in terms of application might possibly occur with respect to the freeze-thaw resistance of the concrete when using cements with low clinker content in particular.

ecra has finalized its report on CCS

One year ago the Technical Advisory Board initiated the ecra report on CO_2 Capture and Storage (CCS) which was finalized in spring 2007. The report provides a first overview of CCS and potential implications which can be foreseen for the cement industry.

Currently, CCS is about to be installed in the power sector on a demonstration scale. The ecra report shows that in general avoidance costs of up to 40 to 50 Euros per ton of CO_2 can be expected. It is clear that such costs would have a severe impact on the competetiveness of the cement industry. However, since a detailed technical understanding of CCS is still pending the ecra Technical Advisory Board has decided to start a second phase of looking into CCS and its potential application for the cement industry. The Board initiated a two year programme focussing on oxyfuel and post-combustion technology. The project will be financed by the ecra members and industrial partners willing to contribute and to benefit from the discussions within the project team. ecra will keep its members updated on the progress of phase II. Since the report on phase I had been made available to ecra members in spring the Board decided to make it available to the general public as well. It can now be downloaded from ecra's website.

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