Contents

Efficient use of waste fuels in the cement manufacturing process ........................................... p. 2
Modern techniques used in the industry for quality control of cement ........................................ p. 3

Next ECRA events:

- Alternative Fuels: Quality and Environmental Control
  8-9 April 2014

- Quality Control of Cement
  20 May 2014
Efficient use of waste fuels in the cement manufacturing process

Pre-treatment and quality surveillance as decisive steps for efficient co-processing

Over the last decade the European cement industry has gained extensive experience in the use of alternative fuels in the clinker burning process. The simultaneous recovery process of energy and material is carried out in an environmentally responsible manner. This is proven on the one hand by the continuous and periodic control of the emissions of major pollutants. On the other hand, the alternative fuels are subject to very sophisticated quality assurance systems where necessary.

Producing clinker and cement is – like other industrial activities – a resource and energy intensive process. The use of alternative fuels reduces the corresponding amount of fossil fuels needed. The overall environmental impact of the operations is therefore also reduced. It is also important to note that the clinker burning process offers the unique possibility of a simultaneous recovery of energy and recycling of resources. This so-called co-processing of wastes is an advanced and innovative recovery process. In the latest revision of the Best Available Techniques Reference Document, co-processing in the cement industry is also considered as a best available technique (BAT) in Europe. Besides this, strict legal requirements have to be met by the operators of cement kilns in Europe.

**Legal requirements**

Cement kilns utilising waste in Europe as a fuel are subject to the European Directive on Industrial Emissions (2000/75/EU).

In addition to the general requirements on the environmentally responsible operation of industrial facilities, annex VI of the Industrial Emissions Directive (IED) covers the requirements on dedicated waste incinerators as well as the so-called co-incineration plants (i.e. industrial facilities such as cement kilns using waste fuels).

In so doing, the IED harmonises the European legislation for the incineration of waste. The co-incineration plants have to be operated according to the same environmental standards as the incinerators. The main idea of the IED and its annex VI is based on the regular control and monitoring of the emissions of the respective industrial facilities. Table 1 compares the emission limits that have to be met by clinker kilns co-incinerating waste with the respective figures of the European Waste Incineration Directive (WID, 2000/76/EC), which has been replaced by the IED. Beside these legal requirements, the alternative fuels themselves also have to meet strict specifications.

**Turning waste into fuel**

Selected waste materials with recoverable calorific value can be used as fuels in cement kilns if they meet strict specifications. In most cases a specific pre-processing of the waste has to be carried out in order to provide a suitable alternative fuel for the clinker burning process. Today, the cement industry in co-operation with waste management companies has developed suitable pre-treatment practises to produce alternative fuels. These sophisticated processes allow even mixed waste streams to be converted to high quality alternative fuels for cement plants. Quality control and testing procedures should be incorporated into the waste processing plant. They are essential for the implementation of a monitoring and surveillance procedure in the pre-treatment process. Important parameters that should be mentioned in this context include the calorific values of the alternative fuels, but the trace element content as well as the content of chlorine or sulphur can also play a decisive role.

**Pre-processing of the waste materials**

Pre-processing in general can be defined as operations which lead to the homogenisation of the chemical composition and/or physical characteristics of the materials. It is normally carried out with the aim of adapting the waste to suit selected pretreatment operation. In this context, typical mechanical processes such as sorting, shredding, grinding are applied.

It should also be pointed out that suppliers and manufacturers of pretreatment facilities have been closely co-operating with the cement industry over the past years. This co-operation has contributed to the success story of sophisticated pretreatment processes today being able to guarantee a stable quality in the waste fuels. This development is also one of the reasons for the continuous increase of the use of alternative fuels in Europe. In 2011 the European cement industry was able to substitute more than 30 % of its overall thermal energy demand by suitable alternative materials (cf. Fig. 1).

**Health and safety aspects**

Co-processing in the cement industry must not have any negative impact on the health and safety of the work-

---

### Table 1: Emission limits as per the former WID and the IED: Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>IPPC / WID</th>
<th>New IED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dust</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>HCl</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>HF</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NO_{x}</td>
<td>800 / 500 existing / new kilns</td>
<td>500 possible for long and legal kilns until (max. 800)</td>
</tr>
<tr>
<td>Cd + Tl</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Hg</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Dioxins + Furans (ng/Nm³)</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>SO_{2}</td>
<td>raw material exemptions possible</td>
<td>raw material exemptions possible</td>
</tr>
<tr>
<td>Total organic carbon</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>CO</td>
<td>ELV can be set by the competent authority</td>
<td>ELV can be set by the competent authority</td>
</tr>
</tbody>
</table>

Fig. 1: (Table 1)
ers or the surrounding neighbour-
hood. It is therefore important that
the respective pretreatment process-
es are also targeted at reducing occu-
pational health and safety risks which
might derive from the waste fuels.
Furthermore, the feeding systems
have to be adapted to the specific
characteristics of the alternative fuels
in order to avoid any potential risk.
Due to the huge variety of the alter-
native fuels there is still a certain lack
of standard parameters for assessing
these potential risks (for example,
self-ignition). In the worst case it
might be necessary for the plant
operator and plant designer to carry
out measurements in advance in
order to assess the potential risks.

Co-processing as a BAT procedure
As an almost waste free industrial
process, clinker burning is highly
suitable for applying the idea of
doing. The demand for natu-
ral resources is thereby reduced,
overall pollution is minimised and
additional efforts for optional after-
treatment of waste or the necessity
for landfilling are avoided. Thus,
co-processing is fully in line with the
subject matter in the scope of the
European Waste Framework Direc-
tive: It preserves natural resources,
reduces emissions, uses the intake
material in the product and recovers
more than 80 % of the energy in the
fuels.

These impressive figures show the
potential contribution of the European
cement industry to the modern and
efficient recovery of alternative re-
source. Besides all other advantages,
the industry can also play an impor-
tant role with regard to environmen-
tally efficient waste management.

Modern techniques used in the
industry for quality control of
cement

Methods such as X-ray diffraction and the Rietveld analysis provide
new opportunities

Quality control of cement has a long
tradition in Europe and worldwide.
Already in the 19th century the first
standards for cement were pub-
lished. Since those early days many
further developments have taken
place. The Construction Products
Directive and later the Construction
Products Regulation set a frame-
work to remove barriers to trade in
the European market. National re-
quirements have been consolidated
in European standards and testing
methods have been harmonised. In
addition, techniques for quality con-
trol have also been improved. Tradi-
tional physical and chemical meth-
ods are still used, particularly as ref-
ence methods for quality control.
Nevertheless, modern online and in-
line analysis has become more and
more established.

The cement industry realised very
early that standardised rules are not
only helpful for customers, but also
for suppliers to ensure the quality
of cement and thereby the safety
and durability of construction works.
Cement standards, published as early
as in the late 19th century, were with-
out doubt among the first standards
ever for industrial products. Require-
ments on the product as well as cor-
responding testing methods were
laid down at that time. Today we may
smile at some of these old rules, for
example, that 60 kg is convenient as
the weight of one cement bag as this
is “transportable with ease”. Other
original rules remain valid in Europe
to this day. For example, mortar
specimens for strength determination
are still produced with “3 weight
parts of normal sand and 1 weight
part of cement”, and testing is car-
ried out “after 28 days’ hardening”.
Fig. 1 shows a historical “rupturing
device” used in the 19th century for
the determination of the tensile
strength of mortar specimens.

European standards have become
essential for the cement sector
The tradition of cement standardisa-
tion at an early stage was continued
by CEN, the European Committee for
Standardisation. In 2000, EN 197-1
“Composition, specifications and
conformity criteria for common
cements” was published as the first
harmonised European standard for
a construction product. EN 197-2
“Cement – conformity evaluation”
was released in parallel.

Due to its importance for the safety
of construction works, the assess-
ment and verification of constancy
of performance (AVCP) of cement
follows the most rigorous AVCP sys-

Figure 1: Use of alternative materials as thermal energy in the European cement industry

Data covers about 96% of the plants producing clinker in the EU28

Source: CEMBUREAU-GNR, November 2013.

Figure 1: Use of alternative materials as thermal energy in the European cement industry
These should be automatatable and fast in order to enable real-time production control. Their equivalence to the reference methods must of course be demonstrated in each case.

**Modern methods for quality control of cement**

Examples of modern automated analysis in cement plants are X-ray fluorescence analysis (XRF) and X-ray diffraction (XRD) combined with the Rietveld method. XRF is applied for the chemical analysis of, for example, cement and its constituents, in particular clinker. The chemical results can be used for the calculation of the “theoretical” phase composition of clinker and thus for the control of the clinker burning process. However, this method according to Bogue postulates completed chemical reactions in the kiln and does not for instance take into account the influence of burning conditions.

As an alternative, X-ray diffraction and the Rietveld analysis have become established in the cement industry over the past 15 years. The method was developed already in 1967 by Hugo M. Rietveld for crystal structure refinement using neutron scattering data. As a result of the improvement of X-ray detectors and computers needed for the calculation of the complex algorithms, the method can also be used today for quantitative phase analysis, for example, of clinker and cement. *Fig. 2* shows an example of a Rietveld analysis of a cement sample. The method provides information not only on the phase composition, but also on crystallographic details. For example, it is possible to distinguish between cubic and orthorhombic calcium aluminate $C_3A$ as clinker phases. These modifications show a different hydraulic reactivity and can influence the hydraulic properties of cement, i.e. setting time, workability and microstructure development.

XRF and XRD can both be implemented as classical online methods in cement plants. Samples are automatically taken in the process and sent to a central laboratory, for example, using a pneumatic tube, for further preparation and analysis. The whole procedure is much faster and needs less manpower than traditional wet chemistry or clinker microscopy. A direct process control is possible although there is still a minor loss of time between the sampling and the availability of the results.

**Inline testing starting to replace classical online analysis**

As a new trend, inline methods which are directly implemented in the production process are increasingly being introduced in the cement industry. For example, the prompt-gamma neutron activation analysis (PGNAA) can be used to determine the chemical composition of raw material. For this purpose an analyser can be mounted directly on the belt conveyor, where the material is analysed continuously during transport in order to optimise stockpiling. Other examples of inline analysis are mill control systems directly placed at or on the mill. Inline methods are often less precise than online methods, but they have the advantage that no sampling and sample processing is necessary and that a lot of data can be used for continuous process control. However, the equipment should be robust to ensure high availability even under the rough conditions of the cement production process.