“Capacity Building and Strengthening Institutional Arrangement”

Workshop: “Best Available Techniques (BAT)

BREF on Cement Industries

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1. Introduction

1. Introduction

The basic chemistry of the cement manufacturing process begins with the decomposition of calcium carbonate ($CaCO_3$) at about 900 °C to leave calcium oxide (CaO, lime) and liberate gaseous carbon dioxide (CO_2); this process is known as calcination. This is followed by the

clinkering process in which the calcium oxide reacts at high temperature (typically 1400-1500 °C) with silica, alumina, and ferrous oxide to form the silicates, aluminates, and ferrites of calcium which comprise the clinker. The clinker is then ground or milled together with gypsum and other additives to produce cement.

1. Introduction

- There are four main process routes for the manufacture of cement: the **dry**, **semi-dry**, **semi-wet** and **wet processes**:
- **Dry process**: the raw materials are ground and dried to raw meal in the form of a flowable powder. The dry raw meal is fed to the preheater or precalciner kiln or, more rarely, to a long dry kiln.

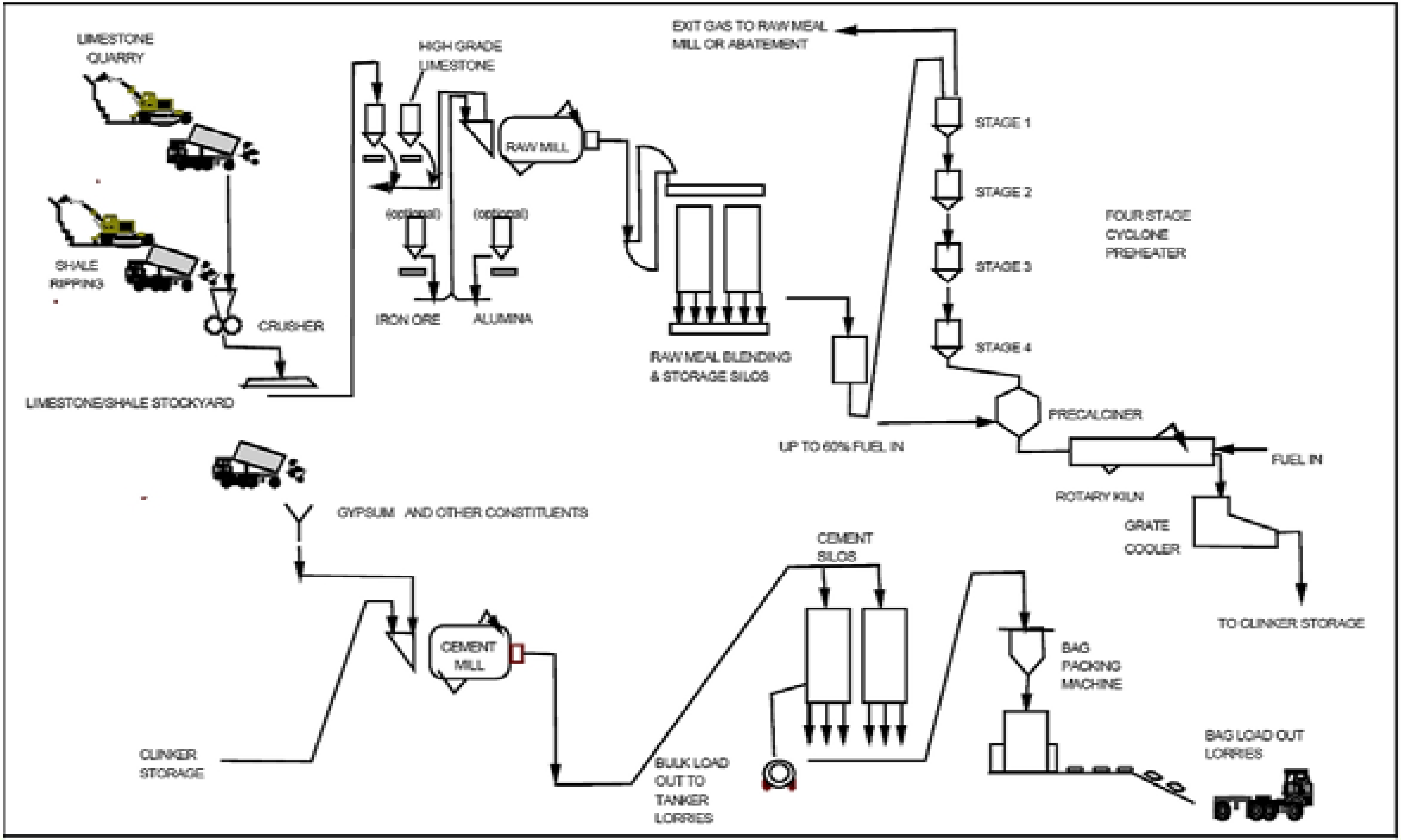
1. Introduction

- **Semi-dry process**: dry raw meal is pelletised with water and fed into a grate preheater before the kiln or to a long kiln equipped with crosses.
- **Semi-wet process**: the slurry is first dewatered in filter presses. The filter cake is extruded into pellets and fed either to a grate preheater or directly to a filter cake drier for raw meal production.

1. Introduction

- **Wet process:** the raw materials (often with high moisture content) are ground in water to form a pumpable slurry. The slurry is either fed directly into the kiln or first to a slurry drier.
- An overview of a dry process precalciner route is shown:

2. Productive cycle



3. Main environmental issues and energy use

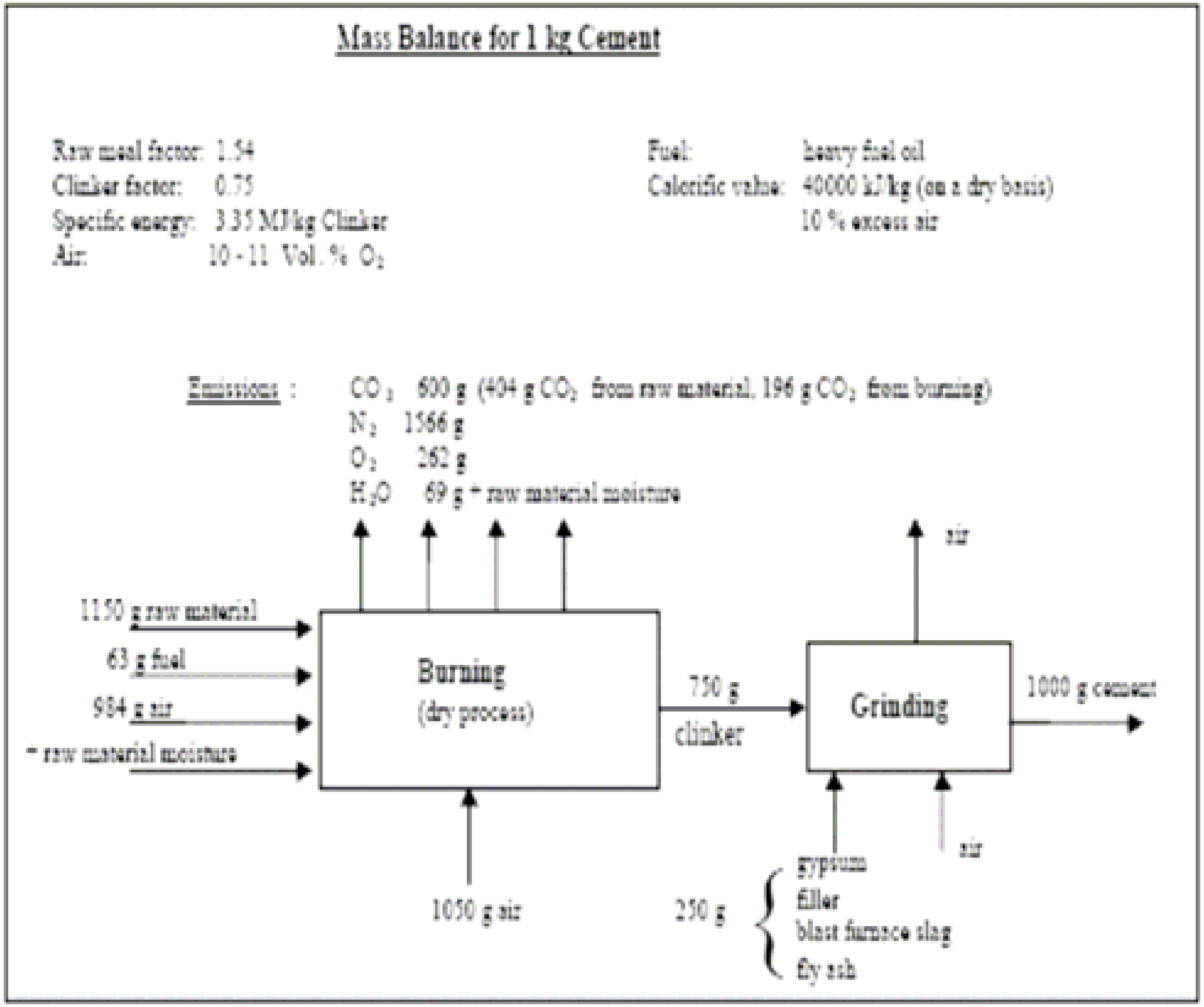
The ***main environmental issues*** associated with cement production are:

emissions to air and ***energy use***.

Waste water discharge is usually limited to surface run off and cooling water only and causes no substantial contribution to water pollution.

The storage and handling of fuels is a potential source of contamination of soil and groundwater.

3. Main environmental issues and energy use



3. Main environmental issues and energy use

Consumption of raw materials in cement production

Materials (dry basis)	per tonne clinker	per tonne cement	per year per Mt clinker
Limestone, clay, shale, marl, other	1.57 t	1.27 t	1568000 t
Gypsum, anhydrite	-	0.05 t	61000 t
Mineral additions	-	0.14 t	172000 t

3. Main environmental issues and energy use

The dominant use of **Energy** in cement manufacture is as fuel for the kiln. The main users of electricity are the mills(finish grinding and raw grinding) and the exhaust fans (kiln/raw mill and cement mill) which together account for more than 80% of electrical energy usage.

On average, energy costs – in the form of fuel and electricity- represent 50% of the total production cost involved in producing a tonne of cement.

Electrical energy represents approximately 20% of this overall energy requirement. The theoretical energy use for the burning process (chemical reactions) is about 1700 to 1800 MJ/tonne clinker.

3. Main environmental issues and energy use

The actual fuel energy use for different kiln systems is in the following ranges (MJ/tonne clinker):

- about 3000 for dry process, multi-stage cyclone preheater and precalciner kilns,
- 3100-4200 for dry process rotary kilns equipped with cyclone preheaters,
- 3300-4500 for semi-dry/semi-wet processes (Lepol-kiln),
- up to 5000 for dry process long kilns,
- 5000-6000 for wet process long kilns, and
- (3100-4200 for shaft kilns).

The electricity demand is about 90-130 kWh/tonne cement.

3. Main environmental issues and energy use

BAT for the Cement Industry

- Identification of key environmental issues: Energy use and emissions on air (i.e. NO_X, SO_2 and Dust);
- Examination of the techniques most relevant to address those key issues;
- Identification of the best environmental performance levels, on the basis of the available data in the EU and world-wide;

3. Main environmental issues and energy use

- Examination of the conditions under which these performance levels were achieved (i.e. costs, cross-media effects, main driving forces involved in implementation of this techniques);
- Selection of BAT and associated emission and/or consumption levels in according to Art. 2(11) and Annex IV of the Council Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC).

3. Main environmental issues and energy use

Process Selection

- The selected process has a major impact on the energy use and air emissions from the manufacture of cement clinker;
- For new plants and major upgrades the best available technique for the production of cement clinker is considered to be a dry process kiln with multi-stage preheating and precalcination;
- The associated BAT heat balance value is 3000 MJ/tonne clinker.

3. Main environmental issues and energy use

General Primary Measures

BAT for the manufacturing of cement includes the following general primary measures:

- A smooth and stable kiln process, operating close to the process parameter set points, is beneficial for all kiln emissions as well as the energy use, by applying:

1. process control optimisation, including computer-based automatic control systems and
2. use of modern, gravimetric solid fuel feed systems.

3. Main environmental issues and energy use

- Minimising fuel energy use by means of:

1. Preheating and precalcination to the extent possible, considering the existing kiln system configuration;
2. The use of modern clinker coolers enabling maximum heat recovery.
3. Heat recovery from waste gas.

3. Main environmental issues and energy use

- Minimising electrical energy use by means of:
- Power management systems;
- Grinding equipment and other electricity based equipment with high energy efficiency.

- Careful selection and control of substances entering the kiln can reduce emissions:
- when practicable selection of raw materials and fuels with low contents of sulphur, nitrogen, chlorine, metals and volatile organic compounds.

3. Main environmental issues and energy use

- **Oxides of Nitrogen**

BAT for reducing NOx emissions are the combination of the above described general primary measures and:

- Primary measures to control NOx emissions:

- Flame cooling;
- Low-NOx burner.

3. Main environmental issues and energy use

- Staged combustion
- Selective non-catalytic reduction (SNCR)

Staged combustion and SNCR are not yet used simultaneously for NOx reduction.

3. Main environmental issues and energy use

- The BAT emission level associated with the use of these techniques is considered to be in the range 200-500 mg NO_x/m^3 expressed as NO_2 on a daily average basis.

- With SNCR the achievable NOx emission level can in the best of cases be less than 200 mg/m^3 if the initial level is not higher than about 1000-1300 mg/m^3 (80-85% reduction), although the majority of installations are today operated to achieve an emission level of 500-800 mg/m^3 (10-50% reduction).

3. Main environmental issues and energy use

- On a sector level the majority of kilns in the European Union is able to achieve less than 1200 mg/m^3 with primary measures.

- By applying SNCR at moderate reduction efficiencies of about 60% this could reduce the NOx emission level to less than 500 mg/m^3.

3. Main environmental issues and energy use

- Selective catalytic reduction (SCR) is BAT with an associated emission level of 100-200 mg NOx/m^3 (as NO_2), based upon SCR being regarded as an available and economically viable technique.

3. Main environmental issues and energy use

- **Oxides of Sulphur**

BAT for reducing SOx emissions are the combination of the above described general primary measures and:

- For initial emission levels not higher than about 1200 mg SO_2/m^3:
  - Absorbent addition

- For initial emission levels higher than about 1200 mg SO_2/m^3:
  - Wet scrubber
  - Dry scrubber.

3. Main environmental issues and energy use

- **BAT** emission level associated with the use of these techniques is in the range 200-400 mg/m^3 expressed as SO_2 on a daily average basis.

- SO_2 emissions from cement plants are primarily determined by the content of the volatile sulphur in the raw materials.

3. Main environmental issues and energy use

- For initial levels up to 1200 mg/m^3 it is possible to achieve around 400 mg/m^3 with absorbent addition.
- The cost for techniques is rather high and it will be a local decision whether the environmental benefits justify the cost.
- A wet scrubber can achieve a level of less than 200 mg SO_2/m^3, irrespective of initial concentration. The SO_2 reduction achieved with dry scrubbing is up to 90%, that corresponds to a clean gas content of 300 mg SO_2/m^3 when the initial SO2 concentration is 3000 mg/m^3.

3. Main environmental issues and energy use

- A wet scrubber can be fitted to all kilns, and a dry scrubber can be fitted to all dry kilns.
- **DUST**

BAT for reducing dust emissions are the combination of the above described general primary measures and:

- Minimisation/prevention of dust emissions from fugitive sources as:
  - Open pile wind protection;
  - Water spray and chemical dust suppressors;
  - Paving, road wetting and housekeeping;

3. Main environmental issues and energy use

- Mobile and stationary vacuum cleaning;
- Ventilation and collection in fabric filters;
- Closed storage with automatic handling system.

• Efficient removal of particulate matter from point sources by application of:

- Electrostatic precipitators with fast measuring and control equipment to minimise the number of CO trips;
- Fabric filters with multiple compartments and 'burst bag detectors'.

3. Main environmental issues and energy use

The BAT emission level associated with these techniques is 20-30 mg dust/m^3 on a daily average basis.

This emission level can be achieved by:
electrostatic precipitators and/or fabric filters
at the various types of installations in the cement industry.

3. Main environmental issues and energy use

- **Waste**

The recycling of collected particulate matter to the process wherever practicable, is considered to constitute BAT.

When the collected dusts are not recyclable the utilisation of these dusts in other commercial products, when possible, is considered BAT.

3. Main environmental issues and energy use

- **Emerging Techniques in the Cement Industry**

- A pilot plant with the capacity of 20 tonnes clinker/day has been operated for six years, between 1989 and 1995, by Sumitomo Osaka Cement Co. Ltd at Toshigi Factory in Japan.
- A 200 tonnes clinker/day large scale pilot plant was constructed in the end of 1995.

3. Main environmental issues and energy use

- The configuration of the 20 tonnes clinker/day fluidised bed cement kiln system is shown in the next figure.
- The system consists of a:

- suspension preheater (**SP**);
- spouted bed granulating kiln (**SBK**);
- fluidised bed sintering kiln (**FBK**);
- fluidised bed quenching cooler (**FBQ**) and;
- packed bed cooler (**PBC**).

3. Main environmental issues and energy use

- Suspension preheater (**SP**) is a conventional 4-stage cyclone preheater which preheats and calcines the raw meal.
- Granulating kiln (**SBK**) is granulating the raw meal into granules of about 1.5 - 2.5 mm diameter at a temperature of 1300 °C.
- In sintering kiln (**FBK**), the sintering of the granules is completed at a temperature of 1400 °C.
- Fluidised bed quenching cooler (**FBQ**) quickly cools the cement clinker from 1400 to 1000 °C.
- Finally, the cement clinker is cooled down to about 100 °C in the packed bed cooler (**PBC**).

3. Main environmental issues and energy use

- The final target of the technical development of the fluidised bed cement kiln (FBCK) system are (in accordance with the feasibility study on a 3000 tonne clinker/day plant and based on the results from the 20 tonnes/day pilot plant):

1. Reduction of heat use by 10-12%;
2. Reduction of CO2 emission by 10-12%;
3. A NOx emission level of 380 mg/m^3 or less (converted to 10% O_2);
4. To maintain the current SOx emission level.
5. Reduction of construction cost by 30%.
6. Reduction of installation area by 30%.

3. Main environmental issues and energy use

- **Staged combustion combined with SNCR**

In theory, a combination of staged combustion and SNCR could be comparable to SCR in performance, that is NOx emission levels of 100-200 mg/m^3.

This combination is considered very promising by suppliers but is not yet proven.

4. Conclusions and recommendations

- SCR technology may be close to being implemented in the cement sector;
- It is recommended to consider an update of this BAT reference document in particular regarding NOx abatement (development of SCR Technology and high efficiency SNCR);
- Other issues:

  - more information about chemical additives acting as slurry thinners;

4. Conclusions and recommendations

- numeric information on acceptable frequency and duration of CO-trips, and
- associated BAT emission values for VOC, metals, HCl, HF, CO and PCDD/Fs

(PCDDs polychlorinated dibenzodioxins,

PCDFs polychlorinated dibenzofurans).

7. References

http://eippcb.jrc.es/pages/Fmembers.htm