030312
Lime (including iron and steel and paper pulp industries)

Process description

In modern ring shaft kilns where there is a particular arrangement of the burners at two levels, the limestone and the firing gases in the upper two firing zones are forwarded in opposing directions, and in the lower section in the same directions, in order to guarantee an effective heat transfer. The firing process takes place at temperatures of around 1000 to 1100°C. Coal has since been nearly completely substituted by liquid and gaseous fuels.

Most of the kilns in current use are based on either the vertical shaft or on the rotary design. There are a few other kilns based on different principles. All of these designs incorporate the concept of the three zones. In some kilns, they are incorporated into one unit, in other they exist as separate units.

In the pre-heating zone, limestone is heated from ambient temperature to over 800 °C by the heat of the gases emerging from the calcining zone. In the calcining zone, the calcium carbonate is decomposed into calcium oxide, thereby absorbing some of the heat of combustion produced by burning the fuel and preheated air. In the cooling zone, quicklime is cooled by part or all of the combustion air, which in turn is preheated.

Mixed-Feed Shaft Kiln

Modern mixed-feed kilns use limestone with a top size in the range 5 to 15 cm and a size ratio fo ca. 2:1. The most widely used fuel is a dense grade of coke with low reactivity and low ash content. The coke size is only slightly smaller than that of the stone so that it moves with it rather than trickling through the interstices. The stone and coke are mixed together and are charged into the kiln in such a way as to minimize segregation.

Double-Inclined Shaft Kiln

In the double-in-clined kiln, the stone moves downwards under gravity past an upper and then a lower hearth, both of which are inclined at about 60 °C. Opposite each hearth are burners mounted underneath arches. the products of combustion and calcination travel upwards through the stone and are removed by an exhaust fan. Most of the combustion air is drawn through the cooling zone.

Although various fuels can be used, they should be selected to avoid excessive build-ups caused by fuel ash and calcium sulfate deposits.

Annular Shaft Kiln

The major feature of the annular shaft kiln is a central cylinder which restricts the width of the annulus, and ensures good heat distribution. The central column also enables part of the combustion gases from the lower burners to be drawn down the shaft and to be injected back into the lower burner chamber. This recycle moderates the temperature at the lower burners and ensures that the final stages of calcination occur at low temperature. Both effects help to manufacture a product with a low $CaCO_3$ level and high reactivity. The kiln can be fired by gas, oil, or solid fuel.

Parallel-Flow Regenerative Kiln

The parallel-flow regenerative (or Mearz) kiln consists fo two or three interconnected vertical shafts. In the first stage, fuel is injected through lances into shaft 1 and burns with combustion air blown down in shaft. The heat released is partly absorbed by calcining the limestone in shaft 1. Air is blown into the base of each shaft to cool the lime. The air in shaft 1 mixes with the combustion gases, including the carbon dioxide from calcination. The mixture passes through the cross-duct into shaft 2, at about 1050 °C. In shaft 2, the gases from shaft 1 mix with the cooling air blown into shaft 2 and pass upwards. In so doing, they heat the stone in the pre-heating zone of that shaft.

During the second stage of the operation, the converse applies. The same amounts of fuel and combustion air are added to shaft 2. The combustion gases plus cooling air pass upwards in shaft 1, heating the stone in the pre-heating zone of that shaft.

The kiln can be fired with gas, oil, or solid fuel.

Rotary Kilns

There are many designs and variants of the rotary kiln. Most use a feedstone with a top size in the range 1 to 6 cm. They operate well on gaseous, liquid, or solid fuels.

One complication often associated with rotary kilns is the build-up of "rings" on the refractory material in the rotary section. They are produced by the combination of lime dust with clay, ash (if present), and sodium and potassium salts. They can be particularly troublesome in kilns fitted with preheaters and in coal-fired kilns. In the latter case, fine grinding of a well selected coal generally minimizes ring formation.

Abatement technologies:

After having released their thermal energy to the materials being fired and the atmosphere of combustion the waste gases are cleaned by the use of fabric filters.

Plant data/European situation

Besides for construction materials lime is used in the pulp and paper and iron and steel industries; therefore, it is likely that large production plants of these sectors also operate lime furnaces. In view of the minor importance of lime production for the European dioxin emissions no attempt was made to get more detailed data.

030312

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Activity data

The activity data (shown in 030312—Table 2) were taken from the national inventories and from production statistics if available. As only 5 countries provided any data a re-calculation of dioxin emissions was omitted due to the inadequate data base.

Emission factors

A few emission factors for lime production are shown in 030312—Table 1 as reported by only 4 countries in their national dioxin inventories. They had been gained either by measurements or by adoption of literature data. Just a narrow range of flue gas concentrations was found depending on the operation conditions.

From these insufficient data no default emission factors could be selected to be used for the emission estimation.

Emission estimation

Due to the inadequate data base a re-calculation of dioxin emissions was omitted.

Conclusions/recommendations

This source category was assigned as potentially relevant due to the large uncertainties which generate a high maximum emission estimate.

The few results from lime production plants indicate the minor relevance of this kind of industry for the total PCDD/F emissions in Europe. Yet, due to the few results it can not be ruled out that single plants may be found in Europe which could have a local impact.

Additional dioxin measurements at lime producing plants are not recommended; investigations should only be carried out if suspicious factors exist that their dioxin emissions might be substantial.

030312

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	Flue gas conc. [ng I-TEQ/m³]			Emission factors [µg/t]			Remark
	typ	min	max	typ	min	max	
A							
B				19	6	29	Data refer to (previous) Swedish studies; N-TEQ and I-TEQ considered to be equal
CH				0.08			*results taken from German inventory [UBA-T 58/96]
D	0.02	0.01	0.04				
Dk							
F	0				?		
NL							not covered specifically in the Dutch inventory;
S	0.01	0.0034	0.03	0.34	0.01	11.6	NTEQ; EF max for 1990 is 94µg/t (major lime producing plants); emission calculated mainly from company information
Uk				0.15	0.02	1.08	

030312—Table 1 PCDD/F air emission factors for lime production from national dioxin inventories

030312

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	Activity rates [kt/a]	
	Inv.	**Statistics**
A		733
B	1853	
CH		
D	,	
Dk		
E		
F		
Gr		
I		
Irl		6470
L		0
N		
NL		
P		
S	423.1	
Sf		
Uk	2000	
Total	**4276**	**7203**

030312—Table 2 Activity rates releated to lime production

References to 030312

see national inventories for further information