040207
Electric furnace steel plant

Process description

Solid substances used in the electric arc furnace (scrap, ferrous alloys, iron slurry) are melted predominantly by electrical energy which is inputted via the electrodes, as well as by fossil energies in the presence of oxygen. Electric arc furnaces have currently a capacity of up 200 tonnes; the duration of heat is in the region of 1 to 4 hours.

Electric Steel Process

In the electric steel process, the heat required is obtained not by oxygen combustion of the accompanying elements in the pig iron, but from electrical energy. The conversion of electrical energy into heat can be achieved by an electric or, induction, or plasma furnace. Electric steel processes are based on the use of scrap, with small amounts. of solid pig iron.

Over 90 % of all electric steel produced is by the use of the a.c. electric are furnace. Three graphite electrodes carry the current through the furnace roof into the charge of metal. The electric arc formed melts the charge at temperatures up to 3500 °C. The Furnace has the following essential components: the vessel or shell with a furnace door and a tapping hole; the roof which can be removed for charging; electrode arms which support the electrodes; tilting equipment for emptying the furnace; the furnace transformer; and the measuring and control equipment.

The melting procedure for the electric are furnace comprises the following stages:

1) Charging
2) Melting
3) Oxidization (decarburization), with an increase in temperature
4) Tapping

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The raw materials (scrap, sponge iron, pig iron, alloying elements, etc.) together with the required additives (lime, coal, ore, etc.) are loaded into special charging buckets which are then emptied into the furnace through a bottom opening. To fill the furnace, two or three charging operations are required, between which the scrap is partially melted. In some installations the scrap is pre-heated prior to the melting process.

The melting process begins with switching on the current and striking the arc. A supplementary blow with oxygen and fuel-oxygen mixtures accelerates melting and reduces current consumption. The duration of the melting period is determined by the electric power limit and the maximum heat load of the furnace shell.

The very rapid development of the d.c. electric are furnace began in the middle of 1985 . Important advantages are:

1) Lower electrode consumption
2) Savings in electrical energy
3) Smaller effect on the electricity supply system
4) Symmetrical distribution of heating in the melt
5) Stirring effect on the melt

The central electrode becomes the cathode, and the melt the anode, the bottom of the furnace vessel being insulated from the wall. Current-carrying elements are built into the hearth, and provide an electrical connection to the melt. The d.c. arc acts as a jet pump, directing the gases in and around the electric arc plasma toward the melt, causing efficient heat transfer from the electrode to the melt.

Abatement technologies:

Owing to their high energy input, modern electric furnaces produces considerable quantities of smoke and waste gas. To minimize environmental pollution, the furnaces are enclosed. Conditions in the workplace and surroundings can thus be maintained to a standard that meets legal requirements.

The waste gases produced in the furnace are extracted through an aperture in the furnace roof, and the dust from various sources in the housing. This is constructed from sound-insulating elements, and reduces the noise level from the furnace to 20 - 25 dB. The waste gas is passed through a cooler which can also serve to recover the heat, and is then dedusted by cloth filters. In some operating conditions, the dust from the electric furnace can contain considerable quantities of heavy metals, such as zinc and lead, and so it is worth recovering them.

Plant data/European situation

Since the iron and steel industry is a sector with a high degree of concentration electric furnace steel plants are likely to be found at any large steel work. For EU 12 total numbers of 203 AC arc furnaces, 4 DC arc furnaces and 38 induction furnaces are reported reported in an Eurostat document (‹1› basic year: 1993). 9 installations (location not specified) are told to be equipped with scrap preheating units.

Activity data

Activity data (shown in 040207—Table 4) were taken from the national inventories and from statistic data. Except for Luxembourg (smaller value from statistic data) and The Netherland (higher value from statistic data) there was quite good agreement between statistic and inventory data.

Emission factors

Emission factors for electric furnace steel plants as reported by the national dioxin inventories are shown in 040207—Table 3. They had been gained either by measurements (Switzerland, Germany, The Netherlands and Sweden) or by adoption of literature data (Belgium, United Kingdom). Dioxin emission factors for electric furnace steel plants depend strongly on operation conditions; if scrap preheating is applied dioxin emissions are up to 5 times higher (040207—Table 3, German results).

The following emission factors were selected to be used for emission estimations:

typical	minimum	maximum
1.0	0.2	5.0

040207—Table 1 Selected emission factors for electric furnace steel plants [µg I-TEQ/t]

Emission estimation

On the basis of the selected emission factors and activity rates the standardised annual PCDD/F emissions are derived. In 040207—Table 5the values obtained were compared to those reported in the national inventories. For all 17 countries considered the following total results are obtained (040207—Table 2):

	TOTAL
national inventories	47.1
Re-evaluation, min	14.8
Re-evaluation, max	370.7
Re-evaluation, typical	74.1
Re-evaluation, combined typical	83.4

040207—Table 2 Summary of re-evaluated typical PCDD/F air emissions [g I-TEQ/a] from electric furnace steel plants

Comparing the values obtained when using the selected emission factors with the values reported in the national inventories generally lower annual emissions are obtained. Yet, in the case of Germany, Spain and The Netherlands higher values are observed. If all 17 countries are included into the total estimation, the typical European total emissions increases by a factor of less than 2.

Conclusions/recommendations

Electric furnace steel plants could be of significant relevance for the total emission of PCDD/F in Europe. However, it seems that in some countries dioxin emissions from this type of plant have not been investigated.

To get more reliable information and to reduce the considerable uncertainties of the calculations in this chapter measurements are recommended at electric furnace steel plants. Primarily, those installations using scrap preheating should be identified and subjected to emission measurements. Spot-check measurements should be done in countries which did not supply any data (like Italy). As the annual dioxin emissions of some countries (e.g. Belgium, United Kingdom) are related only to literature values from other states a certain uncertainty may not be excluded; some measurements should be carried out there, too.

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	Flue gas conc. [ng I-TEQ/m³]			Emission factors [µg/t]			Remark
	typ	min	max	typ	min	max	
A							
B				5 µg/t	0	50	Activity extrapolation; EF estimated from NL and S data
CH				5,7 µg/t			CH-287; additional EF given for diffuse emissions based on PCDD/F content in dust: 4.9 µg I-TEQ/t
D	0.046	0.01	0.26	0.3	0.1	1.8	up to 9.2 ng I-TEQ/m³ found at installations with scrap preheating (closed down in the mean time)
NL				4.3			
S		0.1	1	1.31	0.2	8.6	
Uk				2.65	0.7	10	EFs based on literature data
				1	0.2	5	Chosen values

040207—Table 3 PCDD/F air emission factors for electric furnace steel plants from national dioxin inventories

	Activity rates [kt/a]	
	Inv.	stat.
A		430
B	1284	1664
CH		800
D	8115	8894
Dk		616
E		13647
F		6148
Gr		890
I		26114
Irl		266
L	2056	446
N		456
NL	295	6170
P		722
S	1800	1787
Sf		696
Uk	4120	4395
Total	17670	73711.326

040207—Table 4 Activity rates releated to electric furnace steel plants

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	Annual emissions				
	Inv.	re-estimated			combined
		typ	min	max	typ.
A		0.4	0.1	2.2	0.4
B	6.4	1.7	0.3	8.3	6.4
CH	8.0	0.8	0.2	4.0	8.0
D	2.4	8.9	1.8	44.5	2.4
Dk		0.6	0.1	3.1	0.6
E	13.2	13.6	2.7	68.2	13.2
F		6.1	1.2	30.7	6.1
Gr		0.9	0.2	4.5	0.9
I		26.1	5.2	130.6	26.1
Irl		0.3	0.1	1.3	0.3
L	2.4	0.4	0.1	2.2	2.4
N		0.5	0.1	2.3	0.5
NL	1.3	6.2	1.2	30.9	1.3
P		0.7	0.1	3.6	0.7
S	2.4	1.8	0.4	8.9	2.4
Sf		0.7	0.1	3.5	0.7
Uk	10.9	4.4	0.9	22.0	10.9
Total	**47.1**	**74.1**	**14.8**	**370.7**	**83.4**

040207—Table 5 Comparison of PCDD/F air emission estimates [g I-TEQ/a] for electric furnace steel plants

References to 040207

1EUIron Iron and Steel - Yearly Statistics 1994. Eurostat, Brussels