030310
Secondary aluminium production

Process description

Secondary aluminium production in rotary furnaces

For the secondary production of aluminium, materials containing aluminium such as scrap, machining turnings, and dross are prepared, smelted and refined. Preparation plants are: milling and grading plants for dross, drying installations for machining turnings coated with oils, lubricants and separation agents, paint-stripping plants for scrap and in particular for shredder scrap. Rotary drum or hearth furnaces are used to melt down the aluminium scrap and the materials containing aluminium. Typical melting temperatures are around 700 to 750 °C. The waste gases have temperatures of typically 1000 °C for a normal operation. The burner is off when the materials are loaded; at the temperatures which then govern, an assured destruction of halogenated organic components is not given.

The aluminium which is melted down in the smelting plants is usually treated further in converters to refine and alloy it e.g. with metals such as copper, magnesium, manganese, zinc, or to heat-treat it. The aluminium alloys are subsequently cast into bars or directly processed in molten form in the foundry.

Smelting furnaces have melting capacities of 0.5 to 0.7 tonnes per hour. In rotary drum furnaces, the re-melt process is carried out under a layer of salt. The greater part of the contaminants introduced is collected by the salt such that it forms salt slack. Salt slack is further processed to molten salt, aluminium and impure aluminium oxide. In order to keep the amounts of salt slack as low as possible, recycling materials are processed by mechanical means as much as possible so that the amount of salt required is kept to a minimum.

Secondary production of aluminium in open-hearth smelting furnaces

In modern multi-chamber open-hearth smelting furnaces, clean grade materials used such as wrought alloys are melted down without salt. These furnaces have a preheating of the scrap of up to 400 °C and a post-burning of the waste gases. They are particularly economical from an ernergetic point of view; they are however only for the use of wrought alloys.

Miscellaneous aluminium smelting installations

For using molten aluminium from aluminium electrolysis in aluminium works and for melting material returns and blank scrap, open-hearth furnaces are used for keeping the materials hot, refining and casting into rolling ingots and bars.

Drying of aluminium shavings

A thermal treatment of the turnings is often carried out to reduce the oily processing auxiliaries (machining, drilling suspensions) adhering to the turnings; circulation washing equipment is also used to clean the turnings.

The turnings are dried by the thermal fixtures in rotary drum dryers heated by gas or heating oil; the organic substances contained in the waste gases are extracted and purified in thermal post-burning fixtures. The waste gases are cooled and the particles removed by filtering. The formation of dioxins is possible as the oil-based contaminants adhering to the machining turnings contain certain compounds in which chlorine is bound both organically and inorganically.

Abatement technologies:

The waste gases from smelting furnaces can contain gaseous inorganic chlorine and fluorine compounds in particular, in addition, the waste gases from converters contain chlorine gas. Furthermore and depending on the materials used, chlorinated organic materials can be included by the adherence of paints, lacquers, oils and greases which can lead to dioxins and furans by their incomplete combustion.

The waste gases from smelting furnaces and converters are usually removed together; the amounts of waste gases are usually in the region of between 15,000 and 20,000 m^3/tonne of aluminium. Depending on the materials which are utilised, the crude gases can contain up to 150 mg/m^3 of particles, 100 mg/m^3 of gaseous chlorine compounds, 250 mg/m^3 chlorine compounds (up to 10 g/m^3 in the converter waste gases), and 5 g/m^3 of chlorine gas. The waste gases from dross processing and from the processing of machining turnings are usually removed separately. They contain mainly particles and organic substances.

The most widespread method for the purification of waste gases from melting furnaces and converters is the dry sorption technique for the deposition of HCl and HF using fabric filters. Hydrated lime as the sorbent is administered to the waste gas flow. Pilot and demonstration plants by which hydrated lime - admixed with activated cokes or open-hearth cokes - is added to the waste gases, have begun operations.

The emissions of organic substances are low when the materials utilised in the melting furnaces contain only low amounts of organic materials, as for example in paints, lacquers, greases and oils. The waste gases from installation for the drying of machining turnings are usually purified by a thermal post-burning and fabric-filtering. Waste gases containing particles from dross processing plants are also passed through fabric filters.

Plant data/European situation

No specific information on the number and capacity of secondary aluminium smelters could be obtained. It is very likely, that large producers of primary aluminium also operate furnaces for scrap recycling; certainly , there is a much larger number of small companies producing secondary aluminium.

Activity data

The activity data (shown in 030310—Table 4) were taken from annual production statistics because only 5 countries provided any activity data in their national inventories or other publications.

Emission factors

Emission factors for secondary aluminium production as reported by the national dioxin inventories are shown in 030310—Table 3. They had been gained either by measurements (Germany, The Netherlands and Sweden) or by adoption of literature data (Belgium, France) or estimation (United Kingdom). A relatively narrow range of flue gas concentrations was found depending on the operation conditions and the contamination of the secondary aluminium.

From these data the following default emission factors were selected to be used for the emission estimation:

typical	minimum	maximum
22.0	5.0	100.0

030310—Table 1 Default emission factors for secondary aluminium production [µg I-TEQ/t]

Emission estimation

On the basis of the default emission factors and the activity rates the standardised annual PCDD/F emissions were calculated. The values obtained were compared to those reported in the national inventories. For all 17 countries considered the following results are obtained (030310—Table 2):

	TOTAL
national inventories	64
Re-evaluation, min	9
Re-evaluation, max	174
Re-evaluation, typical	39

030310—Table 2 Summary of re-evaluated typical PCDD/F air emissions [g I-TEQ/a] for secondary aluminium production

Except for Germany and The Netherlands the re-calculated typical annual emissions are generally lower than in the national reports. Consequently, the typical total emission estimate for all 17 countries is less than the total value derived from the few national inventories. This indicates a quite large uncertainty. Most probably the real emission level may be in between of the typical and maximum re-estimation level.

Conclusions/recommendations

Secondary aluminium production is of some relevance for the total emission of PCDD/F in Europe. Here again, all calculations are associated with uncertainties since the emission factors are partly based on assumptions oder literature values.

Some additional measurement programs to determine if the distribution of emission factors found in Germany ‹ 1› also applies to other countries would be worthwhile to gain a more reliable estimation basis. It should be stressed that small facilities may have considerable impact on the local environment if high PCDD/F flue gas concentrations occur.

	Flue gas conc. [ng I-TEQ/m³]			Emission factors [µg/t]			Remark
	typ	min	max	typ	min	max	
A				30			
B				60			Half of Parcom-Atmos. EF used assuming reduced use of hexachloroethane
CH				19			calculated from reported annual emissions and annual production
D	2	0.01	12	4	0.01	167	typ. concentration is geom. mean from UBA/LAI data; 50% percentile from approx. 70 meas. published in ‹1› amounts to 36 µg I-TEQ/m³
F				50			EF taken from German publ. (Lahl)
L	6						
NL		0.1	3		2	35	
S		0.02	0.06		7	100	
UK					5	35	Composite EFs for whole non ferrous metal industry; estimated total emission is 5 to 35 g I-TEQ/a
				22	5	100	Chosen values

030310—Table 3 PCDD/F air emission factors for secondary aluminium production from national dioxin inventories

	inventories	metal stat. kt/a	remark
A	60	44.4	
B	350	3.0	incl. mould casting and semis: 338 kt/a
CH		10.7	
D	536	535.6	
DK		15.2	
E		96.5	
F		230.2	
GR		9.0	
I		353.1	
IRL		0.0	
L	25	0.0	included in Belgian value
N		0.8	
NL	116	150.2	
P		2.0	
S		22.1	
SF		27.5	
UK		244.6	
Total	1087	1745	

030310—Table 4 Activity rates releated to secondary aluminium production

	Inv.	new		
	typ	typ	min	max
A	2	1.0	0.2	4.4
B	20	0.1	0.0	0.3
CH		0.2	0.1	1.1
D	2	12.0	2.7	53.6
DK		0.3	0.1	1.5
E	12	2.2	0.5	9.7
F	10	5.1	1.2	23.0
GR		0.2	0.0	0.9
I		7.9	1.8	35.3
IRL		0.0	0.0	0.0
L	3	0.0	0.0	0.0
N	0	0.0	0.004	0.1
NL	1	3.4	0.8	15.0
P		0.0	0.0	0.2
S	2	0.5	0.1	2.2
SF		0.6	0.1	2.8
UK	13	5.5	1.2	24.5
Total	**64**	**39**	**9**	**174**

030310—Table 5 Comparison of PCDD/F air emission estimates [g I-TEQ/a] for secondary aluminium production

References to 030310

1 Keller H.-J. (1994) : Dioxinemissionen aus Anlagen zum Schmelzen und Raffinieren von Aluminium. 37. Seminar, UTECH BERLIN '94. 65-84