Characterisation of Manganese Furnace Dust and Zinc Balance in Production of Manganese Alloys

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Manganese furnace dust is made up of volatiles and raw materials fines collected from the off-gas during smelting of manganese alloys. Currently, manganese furnace dust is accumulated in large settling ponds. Major factors preventing recycling of the manganese furnace dust to the ferroalloy furnaces are handling, due to its tar content, and accumulation of zinc in the furnaces, which can cause irregularities in their operation. This paper presents characteristics of manganese furnace dust generated in ferromanganese and silicomanganese production at Tasmanian Electrometallurgical Company and analyses zinc balances in light of furnace dust recycling. If manganese furnace dust is recycled to the ferroalloy furnaces *via* the sinter plant, the overall zinc input will increase by 51–143 % depending on charging materials.

KEY WORDS: ferromanganese; silicomanganese; manganese furnace dust; zinc balance; recycling.

1. Introduction

The Tasmanian Electro Metallurgical Company Pty Ltd. (TEMCO) annually produces 250 000 tonnes of ferromanganese and silicomanganese in four electric ferroalloy furnaces, three of them are sealed and one is semi-sealed.[1] In the sealed furnaces, dust and volatiles are removed from off-gas by two stage venturi scrubbers, forming thick, high-solid aqueous slurries, or manganese furnace dust. Manganese furnace dust is collected from the furnace off-gas wet scrubbers, (about 15 500 tonnes per year) and is deposited in settling ponds. In the semi-sealed furnace, the off gas burns at the top of the furnace. The dust in the gas is then collected by fibreglass filtration bags and stockpiled. A sinter plant capable of over 300 000 tonnes per year converts manganese ore fines into sinter to make up part of the feed for the furnaces.

Storage of manganese furnace dust presents a long-term environmental concern, which has stimulated a search for technologies to allow its recycling. Moreover, the furnace dust contains high concentration of manganese oxide, which is suitable to feed in the production of manganese alloys.

A few examples of manganese furnace dust utilisation have been reported in literature. In Hallgren's work,[2] sludge from a sealed silicomanganese furnace was stockpiled. After a few months, it was dry and hard enough to be mixed with re-claimed slag and smelted with other raw materials. Agglomeration of manganese sludge was studied by Matricardi[3] who found that pelletising can be a suitable method. Pellets with sizes in the range of 9.5–19 mm were produced at a rate of 4 to 5 tonnes per hour. When properly agglomerated, the pellets were hard after three days of air settling and appeared to be satisfactory as a furnace charge material. They could also be stored outdoors without any serious deterioration. Maiuolo[3,4] tested briquetting of ferromanganese flue dust sludge with a lime-molasses mixture, pitch and cement. These briquettes could be recycled for smelting.

An apparently attractive way of recycling of manganese furnace dust is its processing in the sinter plant as an additive to the sinter feed. Such attempts have been reported in the literature,[5] however, there is little understanding of the behaviour of zinc and other volatile materials, which are a major concern in the furnace dust utilisation. The authors of this paper undertook a study of sintering properties of manganese ore with addition of furnace dust, and zinc behaviour in the process of sintering. This paper reports characterisation of TEMCO's manganese furnace dust and analyses zinc balances in ferromanganese and silicomanganese smelting if manganese furnace dust is recycled to the furnace through processing in the sinter plant.

2. Characterisation of Manganese Furnace Dust

Samples of manganese furnace dust, taken from different locations of the manganese furnace dust settling pond, were chemically analysed to determine water content and concentrations of carbon, manganese, zinc and impurities, chemical analysis of tar as well as phase characterisation.

2.1. Chemical Analysis of Manganese Furnace Dust

The water content was measured by two methods: oven drying and distillation (following ASTM standard method

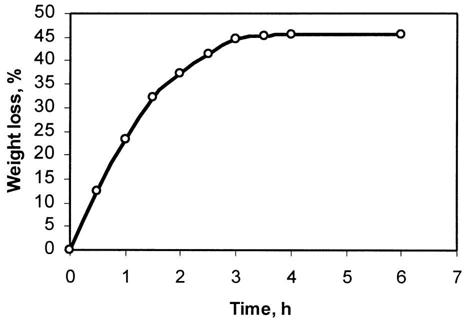

Fig. 1. Weight loss of a sample of manganese furnace dust in an electric oven at 105–110°C.

Table 1. Chemical composition of manganese furnace dust (wt%).

Sample	Moisture	Mn	Zn	C
Middle(0~30cm)	58.2	32.9	1.43	18.6
Middle(30~60cm)	59.1	32.8	1.52	19.5
Middle(60~90cm)	58.0	33.4	1.38	21.1
South Middle(0~30cm)	58.3	34.7	1.06	17.5
South Middle(30~60cm)	55.6	29.9	1.50	21.8
South Middle(60~90cm)	55.3	32.9	0.87	19.0
Northwest C(0~30cm)	30.8	17.0	0.07	10.7
Northwest C(30~60cm)	37.5	21.2	0.44	16.1
Northwest C(60~90cm)	41.9	20.7	0.34	8.5

Note: carbon, manganese and zinc concentrations were measured in dried samples.

D95). Distillation is a standard method for water content in petroleum and petroleum products. The oven drying method gave very close results to the distillation method. This indicates that the content of low boiling point organic compounds in the furnace dust is very low.

Figure 1 shows a typical weight loss curve of a sample of manganese furnace dust at 105–110°C. Drying of the furnace dust is slow as it takes about one hour to remove 50 % of water and more than three hours to complete the drying.

Carbon content was measured in dried samples by LECO analysis. Concentrations of manganese, zinc and other metals in dried samples were determined by X-Ray Fluorescence (XRF).

Water, carbon, manganese and zinc contents in samples of manganese furnace dust taken from different locations in settling ponds are presented in **Table 1**.

The manganese furnace dust taken in the Northwest part of the settling pond is significantly different from other samples because of addition of lime into this region. Samples marked as Northwest C are not typical and can be excluded from further analysis.

The water content of the furnace dust samples taken from the Middle and South Middle parts of the settling pond is in the range of 55–60 %.

Carbon content, measured by LECO analysis, includes carbon of tar and carbonates of different metals. Its level in the "Middle" and "South Middle" samples is in the range 17–22 % (dry basis), with average 20 %. The average manganese content is 33.4 %, and average zinc content is 1.3 %.

2.2. Extraction of Organic Components and Their Composition

Different solvents were employed to extract the tar components from both the original wet and oven dried furnace dust samples. They included hexane, toluene, tetrahydrofuran (THF), pyridine, dichloromethane, chloroform and ethyl acetate. Ethyl acetate gave the best extraction perhaps due to its moderate polarity and better wettability to water containing materials. It extracted 5.1 % tar components (relative to an original furnace dust sample) both from dried and original wet furnace dust samples.

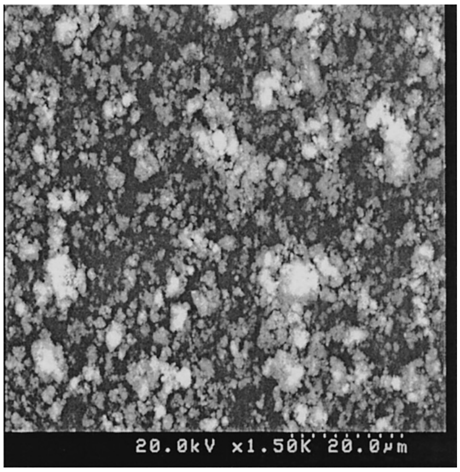

Fig. 2. SEM image of manganese furnace dust.

The composition of the extracted liquids was analysed by the Gas Chromatography-Mass Spectrometry (GC-MS) method. All extracts contain C_{15}–C_{28} aliphatic hydrocarbons, polyaromatic hydrocarbons (PAHs) with 3–6 rings and their derivatives, and sulphur and oxygen containing compounds. The volatile compounds from the extracts cover a wide range of boiling point (230–530°C) and molecular weight (150–400 g). There are heavier components in the extracts, which are not detectable by the GC-MS method. They have a similar chemical structure but higher molecular weights and boiling points.

2.3. Phase and Microanalysis of Furnace Dust

Furnace dust samples after extraction with solvents were analysed by X-Ray Diffractometry (XRD). No zinc containing phases were detected by XRD due to their low contents. The major phases in Middle samples were identified as rhodochrosite ($MnCO_3$), manganosite (MnO) and hausmannite (Mn_3O_4). Phases in the samples from the northern end of the furnace dust settling pond, *e.g.* Northwest C, consist of quartz (SiO_2), manganocalcite ($(Ca,Mn)CO_3$) and hausmannite (Mn_3O_4).

Figure 2 shows the typical SEM image of a sample of manganese furnace dust. It consists of clusters of fine powder with diameter less than 2 μm. The zinc content in the furnace dust is below the detection limit of Energy Dispersive Spectroscopy (EDS) X-ray Microanalysis. A mapping of zinc by Electron Probe Micro-Analysis (EPMA) in a $250\times250\,\mu$m zone of a manganese furnace dust sample shows uniform distribution of zinc.

Analysis of zinc was attempted by the X-ray Photoelectron Spectroscopy (XPS) method. **Figure 3** shows sections of XPS spectra of manganese furnace dust reflecting the binding energies of Zn 2p electrons (a) and S 2p electrons (b). The chemical shifts for zinc in ZnO and ZnS are

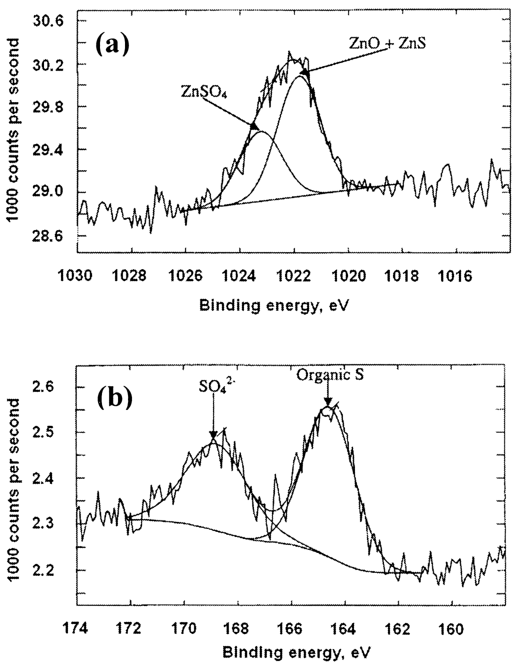

Fig. 3. XPS spectra of manganese furnace dust. (a) Chemical shift of the binding energy of Zn 2p electrons; (b) chemical shift of the binding energy of S 2p electrons.

so close that they cannot be distinguished. The peak of Zn 2p electrons may be fitted with two separate peaks corresponding to $ZnSO_4$ and ($ZnO+ZnS$), with a peak area ratio of about 1 : 2. The XPS spectrum for S 2p electrons consists of two separate peaks corresponding to SO_4^{2-} and organic sulphur. It can be concluded from the XPS analysis that zinc in the furnace dust presents in both sulphate and oxide compounds, with a ratio of 1 : 2 (molar basis) between these compounds.

3. Characterisation of Raw Materials and Products in Ferromanganese and Silicomanganese Production

Analysis of raw materials, products and dusts from the sinter plant and ferroalloy furnaces targets zinc balances in the production of ferromanganese and silicomanganese, which will be considered in Sec. 4.

Moisture, manganese and zinc contents in raw materials, sinter, manganese alloys and slag are presented in **Table 2**. Chemistry of dusts is characterised in **Table 3**.

Zinc content in iron ore is up to 0.1 wt%; in other raw materials it does not exceed 0.02 wt%. Zinc content in ferromanganese and silicomanganese alloys, and especially in slags, is low.

Dust in the sinter plant was collected from different locations of the windbox exhaust gas ducts (samples marked Dust TVC715/x and Dust TVC716). These samples were actually fines, and their zinc content was close to that in the raw materials. Zinc content in dust from the sinter plant electrostatic precipitator was about two times of zinc content in metallurgical grade manganese ore fines.

Zinc content in the dust from the bag house of the semi-sealed silicomanganese Furnace 5 was roughly the same level as zinc in dust from the electrostatic precipitator of the sinter plant, which is only a few hundredths of the zinc level in manganese furnace dust. According to the feed composition, the amount of zinc fed to Furnace 5 is close to other furnaces. The reason for the low zinc content of the dust is not known. It should be noted that the bag house dust contains a significant fraction of a metallic phase. After calcination, the sample weight increased by about 13% as a result of metal oxidation.

Table 2. Characterisation of raw materials and products for sinter plant and ferroalloy furnaces.

			Moisture%	Mn%	Zn%
Sinter plant	Raw material	Mn ore fines	4.94	46.4	0.017
		Return sinter fines	0.09	52.8	0.018
		Sinter hearth layer	0.03	51.7	0.018
	Product	Sinter	0.01	55.9	0.017
Furnaces 1&2	Raw material	Iron ore	1.86	1.0	0.101
		Mn ore chips[1]	2.64	48.6	0.018
		Mn sinter 1[2]	0.52	60.1	0.020
		FeMn remelt	0.24	56.8	0.007
		Mn lump ore 1[3]	1.21	51.0	0.014
		FeMn fines	1.52	51.1	0.007
	Product	FeMn alloy	-	76.5	0.007
		FeMn slag	-	31.0	0.002
Furnace 3	Raw material	FeMn slag	0.09	31.0	0.002
		Iron ore	1.86	1.0	0.101
		Mn sinter 2[4]	0.25	54.8	0.018
		Mn lump ore 2[5]	3.20	50.8	0.015
		SiMn fines	0.95	50.1	0.005
	Product	SiMn alloy	-	66.5	0.007
		SiMn slag	-	9.7	0.004
Furnace 5	Raw material	FeMn slag	0.09	31.0	0.002
		Mn lump ore 2[5]	3.20	50.8	0.015
		Iron ore	1.86	1.0	0.101
		Mn sinter 1[2]	0.52	60.1	0.020
	Product	SiMn alloy	-	66.5	0.004
		SiMn slag	-	9.7	0.002

1 Manganese ore between 6 mm and 12 mm
2 Export grade manganese sinter
3 South African manganese lump ore
4 Metallurgical grade manganese sinter
5 Metallurgical grade manganese lump ore

Table 3. Characterisation of dusts.

Sample	LOI %	LECO C %	Mn %	Zn %
Dust from windbox extraction ducts				
Dust TVC715/3[1]	8.41	6.46	48.1	0.022
Dust TVC715/4	4.96	3.65	47.6	0.020
Dust TVC715/6	6.88	4.91	46.0	0.021
Dust TVC715/7	4.37	2.96	49.5	0.022
Dust TVC715/8	1.51	0.63	49.5	0.019
Dust TVC715/9	0.55	0.51	51.0	0.020
Dust TVC715/10	0.74	0.50	42.0	0.017
Dust TVC715/11	0.24	0.69	44.3	0.017
Dust TVC715	4.02	2.32	38.9	0.017
Dust TVC716	5.29	5.64	38.4	0.018
Dust from electrostatic precipitator				
Dust from field 1	18.19	7.65	26.7	0.037
Dust from field 2	19.40	8.88	27.2	0.038
Dust from fabric filtration baghouse				
Baghouse dust	-12.91	4.40	58.7	0.033

4. Zinc Balance in Current Operation of Ferromanganese and Silicomanganese Production

A zinc balance was estimated from operational data and analysis results (Table 2) of raw materials and products of sintering plant and ferroalloy furnaces in TEMCO. Input of raw materials was taken from TEMCO production records and output of alloys was averaged on weekly basis. The amount of slag for each furnace was calculated from the manganese balance. The amount of zinc in furnace dust formed in smelting operations was taken as the difference between zinc input with raw materials and output with alloys and slag. The average zinc content of Middle and South Middle furnace dust samples in Table 1 was assumed to be the same as the average zinc content of furnace dust from Furnaces 1–3. The total furnace dust was calculated on the basis of total zinc formed in three sealed furnaces. The amounts of furnace dust attributed to different sealed furnaces were proportional to the raw materials to these furnaces. For the semi-sealed Furnace 5, the amount of furnace dust was estimated by assuming the same furnace dust to raw materials ratio as for the sealed furnaces. Then the zinc content in the furnace dust from individual furnaces was calculated according to the amount of zinc in the furnace dust. The manganese content in furnace dust was assumed the same in all furnaces and equal to the average manganese concentration from Table 1.

In current operation of the sinter plant, the dust collected from different locations of the exhaust gas ducts and by the electrostatic precipitator is recycled back to sinter raw materials. In the sinter plant, 90.4 % of zinc remains in the sinter; the rest is possibly lost with the dust passing through the electrostatic precipitator.

The zinc balances for ferroalloy furnaces are summarized in **Tables 4–7**. Coke, coal and slag forming materials such as limestone, quartzite and dolomite contain negligible manganese and zinc, and actually do not contribute to the manganese and zinc balances. They are omitted from the tables.

Ferromanganese Furnaces 1 and 2 operate under identical conditions with slightly different throughputs. Although iron ore contains high level of zinc, about 0.1 wt%, its contribution to the total zinc is relatively low due to its low amount fed into furnaces. The main sources of zinc for Furnaces 1 and 2 are export grade manganese sinter and metallurgical grade manganese ore chips. The overall zinc level in the raw materials of these furnaces is 0.019 % (coke, coal and slag forming materials were not included).

For silicomanganese Furnace 3, which is charged with a significant amount of ferromanganese slag from Furnaces 1 and 2, with very low zinc concentration, the overall zinc level in raw materials is much lower, *i.e.* 0.014 %. Iron ore is the major source of zinc for this furnace.

Raw materials into the silicomanganese Furnace 5 contain less ferromanganese slag and more export grade manganese sinter in comparison with Furnace 3. This increases the zinc level in the raw materials to 0.021 wt%. Major sources for zinc are iron ore and export grade manganese sinter.

For all four furnaces, the zinc contents in alloys and slag

Table 4. Zinc balance for ferromanganese smelting Furnace 1.

Material	Amount ton/day	Mn content %	Mn amount ton/day	Zn content %	Zn amount kg/day	Zn fraction in total Zn, %
Input						
Iron ore	10.5	1.0	0.1	0.101	10.6	13.4
Mn ore chips[1]	133.6	48.6	64.9	0.018	24.1	30.4
Mn sinter 1[2]	149.5	60.1	89.8	0.020	29.9	37.7
FeMn remelt	26.2	56.8	14.9	0.007	1.8	2.3
Mn lump ore 1[3]	78.6	51.0	40.1	0.014	11.0	13.9
FeMn fines	26.2	51.1	13.4	0.007	1.8	2.3
Total			223.2		79.3	100
Output						
FeMn Alloy	225.8	76.5	172.8	0.007	15.9	20.0
FeMn Slag	158.2	31.0	49.0	0.002	3.1	4.0
Furnace dust	4.1	33.4	1.4	1.47	60.3	76.0
Total			223.2		79.3	100

1 Manganese ore between 6 mm and 12 mm
2 Export grade manganese sinter
3 South African manganese lump ore

Table 5. Zinc balance for ferromanganese smelting Furnace 2.

Material	Amount ton/day	Mn content %	Mn amount ton/day	Zn content %	Zn amount kg/day	Zn fraction in total Zn, %
Input						
Iron ore	10.8	1.0	0.1	0.101	10.9	13.4
Mn ore chips[1]	137.7	48.6	66.9	0.018	24.8	30.4
Mn sinter 1[2]	154.0	60.1	92.6	0.020	30.8	37.7
FeMn remelt	27.0	56.8	15.3	0.007	1.9	2.3
Mn lump ore 1[3]	81.0	51.0	41.3	0.014	11.3	13.9
FeMn fines	27.0	51.1	13.8	0.007	1.9	2.3
Total			230.0		81.7	100
Output						
FeMn Alloy	232.1	76.5	177.6	0.007	16.2	19.9
FeMn Slag	164.8	31.0	51.1	0.002	3.2	4.0
Furnace dust	4.2	33.4	1.4	1.47	62.1	76.1
Total			230.0		81.7	100

1 Manganese ore between 6 mm and 12 mm
2 Export grade manganese sinter
3 South African manganese lump ore

Table 6. Zinc balance for silicomanganese smelting Furnace 3.

Material	Amount ton/day	Mn content %	Mn amount ton/day	Zn content %	Zn amount kg/day	Zn fraction in total Zn, %
Input						
FeMn slag	196.9	31.0	61.0	0.003	4.2	7.5
Iron ore	24.9	1.0	0.3	0.101	25.1	47.7
Mn Sinter 2[1]	46.7	54.8	25.6	0.019	8.8	16.8
Met lump ore 2[2]	89.5	50.8	45.5	0.015	13.4	25.5
SiMn fines	26.9	50.1	13.5	0.005	1.4	2.5
Total			145.8		52.7	100
Output						
SiMn Alloy	183.5	66.5	122.0	0.007	12.8	24.4
SiMn Slag	229.2	9.7	22.2	0.004	9.2	17.4
Furnace dust	4.8	33.4	1.6	0.64	30.7	58.2
Total			145.8		52.7	100

1 Metallurgical grade manganese sinter
2 Metallurgical grade manganese lump ore

Table 7. Zinc balance for silicomanganese smelting Furnace 5.

Material	Amount ton/day	Mn content %	Mn amount ton/day	Zn content %	Zn amount kg/day	Zn fraction in total Zn, %
Input						
FeMn slag	66.8	30.7	20.5	0.003	1.4	2.4
Mn lump ore 2[1]	50.1	50.8	25.5	0.015	7.5	13.3
Iron ore	20.0	1.0	0.2	0.101	20.2	35.8
Mn sinter 1[2]	136.9	60.1	82.3	0.020	27.4	48.5
Total			128.5		56.5	100
Output						
SiMn Alloy	148.0	66.5	98.4	0.004	5.9	10.5
SiMn Slag	298.5	9.7	29.0	0.002	6.0	10.6
Furnace dust	3.4	33.4	1.1	1.31	44.6	78.9
Total			128.5		56.5	100

1 Metallurgical grade manganese lump ore
2 Export grade manganese sinter

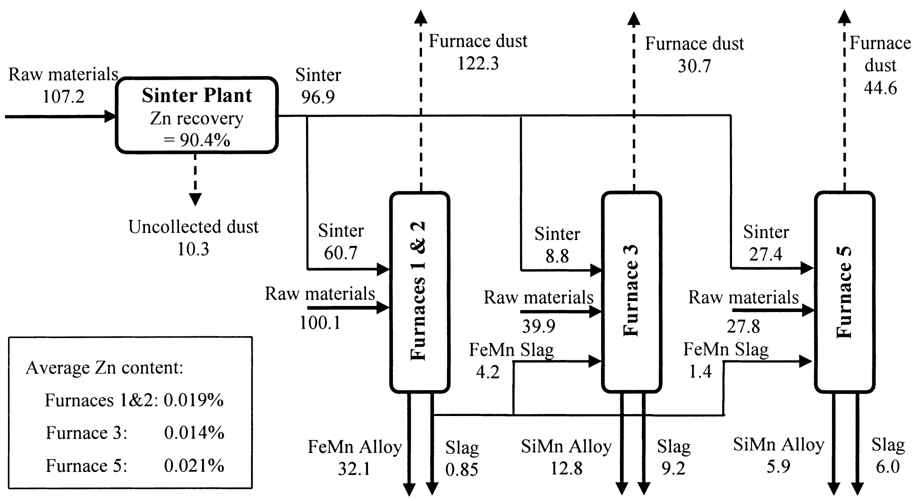

Fig. 4. Schematic zinc flow (kg/d) for current smelting operation.

are low, as most of the zinc is brought out of the furnace with off-gas and subsequently goes into manganese furnace dust: 76.1 wt% of zinc input to Furnaces 1 and 2 transfers to manganese furnace dust *via* the off-gas. For Furnaces 3 and 5, 58.2 % and 78.9 % of zinc enters manganese furnace dust, respectively.

Figure 4 presents the schematic flow of zinc (kg/d) for current smelting production processes. Because only part of the sinter is consumed in TEMCO, the data for sinter plant operation are scaled down to reflect the actual consumption of sinter. The "raw materials" labelled in the figure exclude sinter and slag if they are charged into a furnace, because they are presented as separate streams.

5. Zinc Balance with Manganese Furnace Dust Recycling

Most of zinc input into ferroalloy furnaces with charging materials enters manganese furnace dust, while about 90 % of zinc entering the sinter plant remains in the sinter.

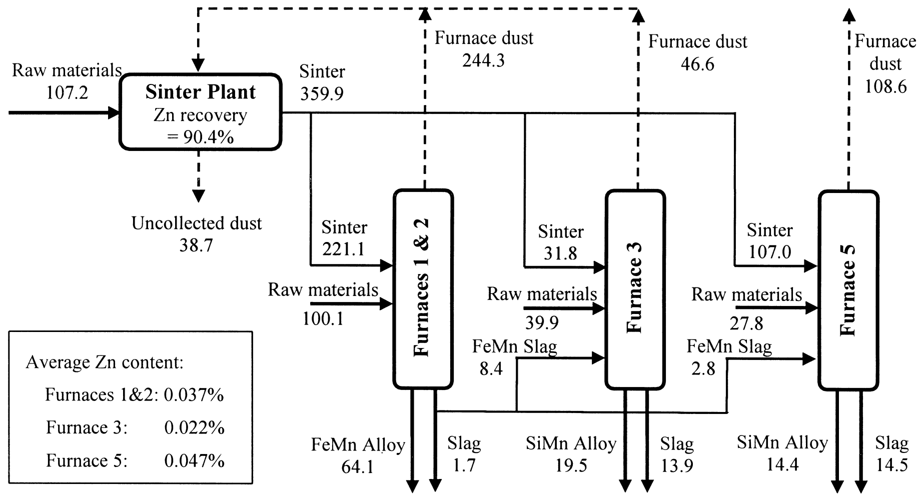

Fig. 5. Schematic zinc flow (kg/d) when all manganese furnace dust from Furnaces 1–3 is sintered and recycled.

Therefore, if manganese furnace dust is recycled through the sinter plant, only a small fraction of zinc in the furnace dust will be removed during sintering. Most of the zinc will be recycled back into smelting furnaces. This will increase the zinc contents in the raw materials of smelting furnaces and, consequently, in furnace dust. The zinc balance shown below evaluates zinc input into ferroalloy furnaces with recycling of furnace dust back into furnaces through the sinter plant.

It was assumed that 90.4% of zinc input into the sinter plant enters the sinter as in the case when furnace dust is not recycled. It was also assumed that zinc partitioning among manganese alloy, slag and furnace dust is not affected by the furnace dust recycling. Change in the amount of sinter due to recycling of furnace dust is expected to be small compared to the total amount of sinter and is neglected. The fraction of sinter in the charge is 61.5% for Furnaces 1 and 2, 8.8% for Furnace 3, and 29.7% for Furnace 5.

The zinc balance in the sintering and smelting processes with recycling of all manganese furnace dust formed in Furnaces 1–3 is presented in **Fig. 5**. Compared to data in Fig. 4, the zinc content in sinter increases by 270%. This causes a dramatic increase in zinc level in the raw materials for smelting furnaces, *i.e.* 100% increase for Furnaces 1 and 2, 51% for Furnace 3, and 143% for Furnace 5. The increase in the zinc level caused by the furnace dust recycling strongly depends on the use of sinter.

In total, 275 kg/d zinc enters the sintering-smelting processes with the raw materials of sinter plant and smelting furnaces (the amounts of zinc contained in recycled furnace dust and in sinter are excluded, as they are internal zinc flow within the sintering-smelting processes). The amount of zinc going into ferromanganese and silicomanganese will be 98 kg/d, which occupies 36% of total zinc input. The zinc amount removed with slag will be 30.1 kg/d, or 11%. Up to 108.6 kg/d (40%) of zinc will go into the furnace dust of the semi-sealed Furnace 5, which is a major route for removal of zinc from the operation chain. The zinc removed with uncollected dust from sinter plant will only occupy 14% of the total zinc input.

Currently, dust from Furnace 5 is collected in the bag house and stockpiled. Zinc content in this dust is small (Table 3), and its recycling would not give a significant increase to the zinc input into the ferroalloy furnaces.

The zinc balance shows that recycling of manganese furnace dust into ferroalloy furnaces will not put zinc level in charge materials above the limit, which is estimated to be 0.05 wt%. However, changing composition of supplied raw materials, sinter and other operational factors may put zinc content above this level. Therefore, to make manganese furnace dust recycling sustainable, zinc should be removed before the furnace dust is recycled to the ferroalloy furnaces. The authors of this paper has studied reduction of zinc oxide in the furnace dust and sintering properties of manganese ore with furnace dust addition. Results of these studies will be presented in other papers.

6. Conclusions

Manganese furnace dust taken from the settling ponds contains 30–60% water, carbonaceous materials or tar, and metal oxides. The carbon content of the dried furnace dust is about 20% and the average manganese and zinc contents are 33.4 and 1.29%, respectively.

Manganese in the furnace dust is present in the form of oxides MnO and Mn_3O_4, and carbonate $MnCO_3$, while zinc is in the form of oxide ZnO and sulphate $ZnSO_4$. The manganese furnace dust is composed of fine powder with size less than 2 μm.

Extraction and GC-MS analysis of the tar components showed that they are aliphatic hydrocarbons and poly aromatic hydrocarbons, their derivatives, and sulphur- and oxygen-containing compounds. The carbonaceous materials cover a wide range of carbon number (15–28) and boiling point (230–530°C). Light hydrocarbons were not detected.

Zinc enters ferroalloy furnaces with manganese and iron ores, alloy fines and sinter. The main source of zinc for Furnaces 3 and 5 is iron ore, which contains up to 0.1% zinc. Manganese ores (fines, chips and lumps) and sinter contain zinc at a level of 0.02%. Zinc content in ferromanganese and silicomanganese is below 0.01%; slag contains zinc at the level of 0.002 wt%. Most of zinc in the raw materials goes to manganese furnace dust.

If manganese furnace dust is recycled to ferroalloy furnaces through the sintering plant, the overall zinc input will increase by 51% for silicomanganese Furnace 3, by 100% for ferromanganese Furnaces 1 and 2, and by 143% for the silicomanganese Furnace 5. Although this increase can be tolerated in current operation of TEMCO, more sustainable utilisation of manganese furnace dust should include partial zinc removal.

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