ENVIRONMENTAL CHALLENGES FOR NORWEGIAN MN – INDUSTRY

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ABSTRACT

Eramet and Tinfos are two producers of manganese alloys in Norway, which have worked hard for several decades to improve both the internal and external environment. Furnaces producing ferro- and silico- manganese alloys generate large amounts of off-gas that contains substantial amounts of dust, heavy metals and organic by-products. The dust is separated from the gas in venturi scrubbers by washing with water. The water is cleaned and recirculated, and the surplus water coming from moisture in the raw materials, is discharged to the adjacent fjords after further treatment. Emission figures show that the discharge of suspended solids, manganese, zinc and PAH (polycyclic aromatic hydrocarbons) have been reduced substantially over the last three decades as a result of process improvements and installation of state of the art environmental control measures. The two plants were the first world wide to install mercury cleaning of the off-gases from the furnaces. Mercury emission reduction has exceeded 90%. Concerning other environmental issues, such as utilisation of off-gases for energy recovery and chemical purposes, both plants have achieved good results.

Major effort in the environmental work has come from the plants themselves, but other players like FFF, The Norwegian Ferroalloy Producers Research Association, and SFT, The Norwegian Pollution Control Authority, have contributed to the achieved results.

1. INTRODUCTION

Pollution control and reduction of environmental impact have been major issues for the Norwegian authorities during the last decades. Most types of industrial activities have been focused, and emissions of the most important hazardous pollutants have been significantly reduced during this period.

The Norwegian ferroalloy industry has contributed to these reduced emissions through a combination of improvements based on research and monitoring carried out by the Norwegian technical university (NTNU), research organisations such as Sintef, internal process development, cooperation with technology-equipment suppliers and encouragement-pressure from the environmental authorities.

The achievements made in the Norwegian ferroalloy industry have been strongly influenced by the good co-operation between the different companies, and in particular through work sponsored by The Norwegian Ferroalloy Producers Research Association (FFF) since its start up in 1989. Objectives of the research work have been to describe the situation, level of effluents, and to improve the basic knowledge of the process and its environmental impact. FFF has completed several relevant projects and environmental problems have been reduced through improved furnace operation, the choice of raw materials or by improved design of the process.

The formal cooperation agreement between Tinfos and Eramet on environmental issues has speeded up development work and implementation of environmental solutions.

Tinfos and Eramet Norway have, through FFF, a formal cooperative agreement with the environmental foundation Bellona in order to exploit one another's professional competency in order to improve the company's environmental record.

Both Tinfos and Eramet are ISO 14001 accredited.

This paper seeks to present an overview of some of the environmental problems that Tinfos and Eramet have encountered and how these have been solved. Both companies have focused on;

- Emissions of suspended solids, heavy metals and PAH to the sea.
- Dust and Hg emissions to atmosphere.
- Waste energy utilization.

Data from Eramet Sauda is used here as an example, but the same or tighter constraints apply to Eramet Porsgrunn.

2. TINFOS AND ERAMET SMELTING PLANTS

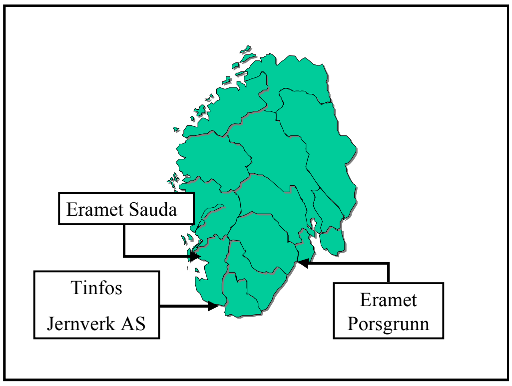

Figure 1: Position of Kvinesdal, Sauda and Porsgrunn smelters in southern Norway

Tinfos: The Tinfos Manganese Plant in Kvinesdal, Norway was built in 1974. The plant was originally built with 2x45 MVA closed submerged arc furnaces. The third furnace came on stream in October 2000. Silicomanganese is the main product with an annual production of 190,000 tons made up of standard, low carbon and low boron qualities. The furnaces may also produce high carbon ferro-manganese, with a production capacity of 240.000 tons per year.

The off-gas from the furnaces, consisting of mainly CO, CO_2 and H_2, goes through a 3 stage venturi scrubber to remove dust. The CO rich off gas is then burned in a boiler to produce steam for generation of electricity. Before the burnt gas is discharged to atmosphere it goes trough a separate cleaning step to remove mercury. The facility for mercury removal is specially designed for the purpose. Water from venturi scrubber 1 and 2 is circulated back to the cleaning step after the dust is settled in a sedimentation tank and separated in a vacuum filter. The sludge is taken to a secure landfill classified to store special wastes. The water used in the third venturi scrubber is treated in a separate cleaning plant where dust, heavy metals and PAH are removed.

In the tapping area hoods are installed and connected to baghouse filters. The dust collected is deposited together with sludge from the gas cleaning plant.

A description of the cleaning facilities is given in figure 2.

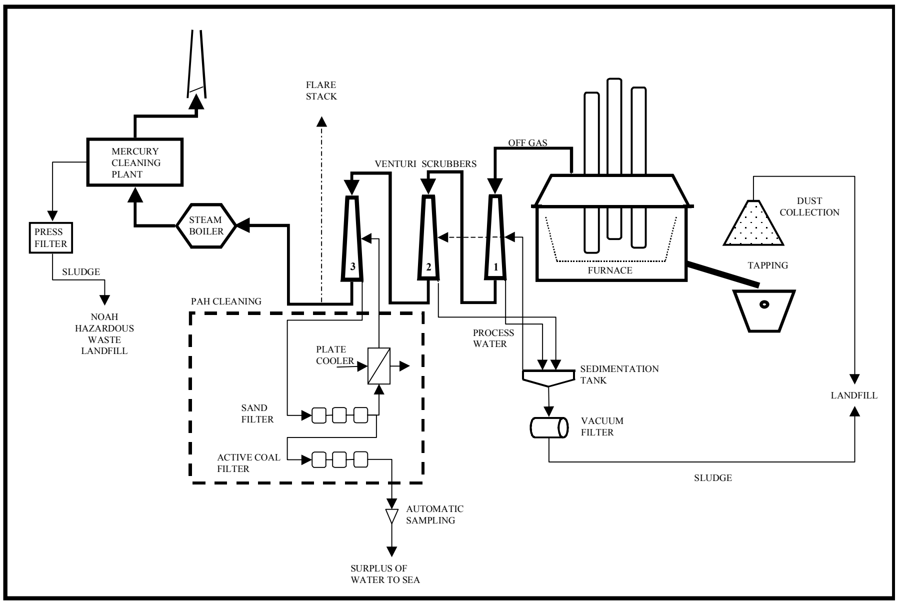

Figure 2: Schematic illustration of the cleaning facilities at Tinfos Manganese, Kvinesdal

Eramet: Eramet Manganese is a vertically integrated company comprising of the Comilog mine in Gabon, submerged arc furnace operations in Norway, USA, and France, and blast furnace operations in China. The Eramet smelter in Sauda, Norway plant was built in 1915 and after substantial modifications now comprises two closed HCFeMn submerged arc furnaces rated at 30MW and 40MW producing around 220,000 mt/year HCFeMn. Feed to the furnaces is Comilog ore, various ores from S. Africa and Comilog sinter. Approximately 120,000mt of the HCFeMn is refined to medium and low carbon ferromanganese in an oxygen refining converter (MOR).

Raw gases from the furnace containing mainly of CO_2, CO and H_2 are first cleaned in a 3 stage venturi scrubber to remove dust, then an electrostatic filter to remove residual dust and tars before entering the activated carbon bed of the mercury absorption unit. Some of the clean gas is used for process heating and the rest is burnt in a flare stack. Water from the scrubbers passes through a sedimentation basin and primary thickener to remove majority of the dust, heavy metals and PAH before being recirculated back to the scrubbers. Surplus water for discharge to the sea is treated with additives to precipitate heavy metals, before passing through a lamella thickener, a sand filter and an active charcoal filter. Sludge is dewatered in a centrifuge before being deposited in a secure landfill. Fumes from the furnace roof area, tapping hoods and metal-slag transfer stations are collected in bagfilters. The Mn rich slag from the HCFeMn furnaces is used as feed for the production of SiMn at Eramet Porsgrunn and Tinfos. The dust from the refining of HCFeMn to MCFeMn is also captured in a bagfilter and sold as colour additive, animal feed supplement and to the electronics industry. A schematic of the cleaning facilities is given in figure 3.

3. PLANT START UP PERIOD AND EMISSIONS LICENCE

Tinfos: When Tinfos started the first two furnaces in 1974 the cleaning facilities were quite simple. The water used in the venturi scrubbers was cleaned in a sedimentation tank with a volume of 660 m^3. The surplus of water coming from moisture in raw materials flowed directly into the sea after sedimentation. As seen in table 1 the licence for the first years concerned only suspended solids and dissolved manganese. In addition, Tinfos had permission to run the furnaces without any cleaning off the water for 2,5% of the operating time. In this periods many tonnes of suspended solids may flowed into the sea.

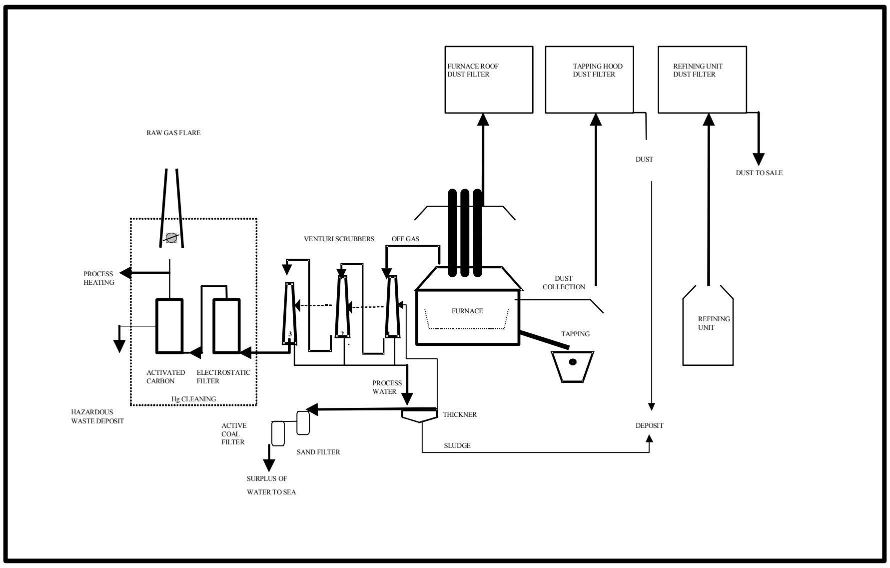

Figure 3: Schematic illustration of the cleaning facilities at Eramet Manganese, Sauda

Table 1: Summary of licence for effluent from Tinfos Manganese, Kvinesdal

	Suspended matter, (kg/year)	*Mn to sea (kg/year)*	*Zn to sea (kg/year)*	*PAH to sea (kg/year)*	*Hg to air (kg/year)*	*Operating time*
1974-1982	9490	949				97.5%
1983-1992	11680	2555				97.5%
1993-1994	1402	280	140	70	100	
1995-1999	2099	420	240	24	100	
2000	2099	420	240	24	56	
2001-2004	2099	420	240	24	25	
2005-	2099	420	240	24	20	

Eramet: The Electric Furnace Products Company Limited (EFP) commissioned the Sauda smelting plant in 1921. Furnace 11 (26MW), the first of the modern generation of furnaces started producing SiMn in 1967 followed by furnace 12 (40MW) for making HCFeMn in 1973. The Metal Oxygen Refining converter (MOR) for refining HCFeMn was built in 1975. The basic water cleaning plant was constructed in 1977 and recirculation of water back to the furnace scrubbers was started in 1990. The Sauda sinter plant was shut down in 1998 partly to reduce the dust emissions to the atmosphere. The scrubber plant for cleaning mercury from the furnace gases was installed in 2001 to take care of the increased Hg load from Comilog ore. Furnace 11 was converted to HCFeMn in 2003 and Sauda became a totally HCFeMn smelter. A bag filter was installed to clean gases from over the furnace roofs in 2005 and modifications to water cleaning plant were made to increase zinc removal efficiency in 2006.

Table 2: Summary of licence for effluent from Eramet Manganese, Sauda

	Suspended matter, (kg/year)	*Mn to sea (kg/year)*	*Zn to sea (kg/year)*	*PAH to sea (kg/year)*	*Hg to atmosphere (kg/year)*
1995-2002	17500	2028	4380	350	
2003-	4000	400	400	50	36

4. DEVIATIONS FROM EMISSION LIMITS

There are occasional furnace operating problems or instances when the operation of the cleaning facilities are disrupted that might result in the emission limits being temporarily exceeded. In such cases a deviation report is written, describing the incident, the quantities discharged and what kind of actions were taken. The report is submitted to SFT and the further line of action depends of the answer from SFT. Normally SFT accept the actions taken, and so far no furnaces have been closed down for long periods due to problems with emission limits.

5. MEASUREMENT OF EMISSIONS

5.1 To Air

Tinfos: Dust measurements are performed from all emissions points; after the mercury cleaning plant, after the baghouse filter collecting dust from the tapping area and finally after baghouse filters placed in the crushing plants. Samples are taken manually 2 times a year.

Eramet: A video camera is sited over the furnace building roof and other cameras are sited at strategic positions in the furnace hall to monitor dust emissions. The central control room operator surveys the camera screens for any discharges and a continuous video recording helps with fault finding and planning improvements. Dust load is continuously measured from the furnace roof, MOR and crushing plant bagfilter stacks. Sauda laboratory measures dust load 3 times per year to check the on-line measurement and an independent laboratory makes a control measurement 4 times per year for dust load, Hg (gas), Hg (solid) and heavy metals (Cu, Cr, Co, Mo, As, Cd, Ni, Zn, Pb). Dust drop-out from the atmosphere is sampled at five locations in the local community on a monthly basis and compared to a reference sampler located some distance from the smelter as an indicator of background levels. Hg is sampled three times per week in the stack from the Hg scrubber unit.

5.2 To Gas

Tinfos: Off gas from the furnaces is continuously analysed for CO, CO_2, H_2 and O_2 for control purposes. After the mercury cleaning plant the off-gas is continuously analysed for mercury. Data from the analyses are stored for reporting.

Eramet: Raw gas to the mercury scrubbing unit is continuously analysed for CO, CO_2, H_2, O_2 and Hg. Gas from the mercury scrubber is analysed for Hg (gas) 2-3 times per week and for Hg (gas), Hg (solids), dust loading and heavy metals four times year.

5.3 To Discharge Water

Tinfos: A quantity-proportional sample is continuously taken from the discharged water. This is analysed on a daily basis for Mn, Zn, suspended solids and pH. Monthly samples are taken for heavy metal analyses. These samples are folded up to six months samples, which are analysed. If any irregularities occur, the monthly samples are saved, and might be analysed separately. PAH analyses are performed every week on the water discharged from the cleaning plant.

Eramet: A daily quantity-proportional sample is taken from the discharged water and analysed for total Mn, dissolved Zn, pH and suspended solids. A monthly sample is analysed for heavy metals, Hg, PAH and suspended solids. The Norwegian water authority, NIVA, take independent water and sediment samples from the surrounding fjords and lakes.

5.4 To Soil

Tinfos: A measurement program has been performed over the last 12 years where moss samples from the surrounding areas have been analysed for mercury. Since the specific moss used in the survey takes nutrition from the air only, it is a good indicator of air-borne pollutants. The analyses show that moss samples close to the plant have a higher mercury content compared to background levels, but the levels are still low compared to heavily polluted areas. After the start up of the mercury cleaning plant, the mercury levels have decreased.

Eramet: Moss samples are occasionally taken from the surrounding mountains and analysed for heavy metals and zinc.

5.5 To Landfill

Tinfos: Runoff water from the landfill is sampled three times a week and folded up to one sample analysed for suspended solid and pH. One sample every month is added up to a six month sample, analysed on heavy metals and PAH.

Eramet: A daily sample of the sludge from the water cleaning plant is analysed for total solids. The daily samples are collected together and analysed for heavy metals and Hg every three months. Run-off water from the sealed sludge disposal site is sampled once per month and analysed for Mn, Zn and suspended solids. A quarterly run-off water and test well samples are analysed for heavy metals, CN^-, PAH and phenols.

6. POLLUTION CONTROL MEASURES

6.1 Reduction Of Dust Emissions To The Atmosphere

Tinfos: In 1996 Tinfos installed hoods in the tapping area and baghouse filters to reduce dust emissions from these areas. Dust emissions were reduced from approximately 30 tons each year to 20 tons per year. Since 1996 continuous improvements have reduced the dust emissions to approximately 10 tons per year.

Eramet: The Sauda sinter plant ceased operating in 1998, partly to reduce the dust emissions. Continuous improvements to tapping hoods and metal pouring areas have been carried out since 2003, and a bagfilter plant was installed in 2005 to clean the discharges from the furnace roof area. Extra extraction fan capacity and further improvements in the tapping and metal pouring areas will be implemented in 2006.

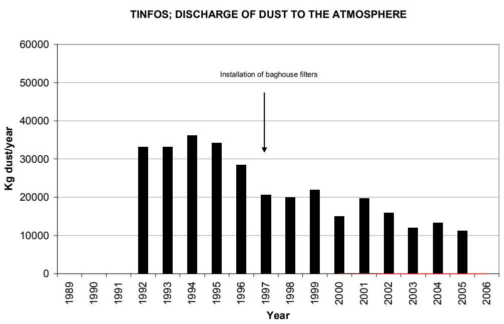

Figure 4: Tinfos dust emission to atmosphere

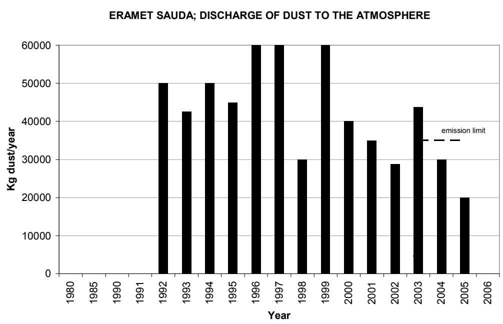

Figure 5: Eramet Sauda dust emission to atmosphere

6.2 Removal Of Mercury From The Furnace Exhaust Gases

Tinfos: In 1993 Tinfos detected mercury emission to air. In the 1990's the mercury emission to air varied between 70 and 100 kg/year. Together with Miltec, Tinfos developed a mercury cleaning process, which is based on oxidation of Hg° in the off-gas using sodium hypochlorite. After oxidation in a washing tower, the mercury is precipitated as mercury sulphide (HgS) by addition of disodium sulphide. The mercury sulphide is removed from the process in a press filter. The mercury containing sludge is treated as hazardous waste and delivered to NOAH for disposal in a sealed landfill. NOAH is the national center for treatment and deposition of hazardous waste. After the installation of the mercury cleaning plant the emission of mercury has been reduced by approximately 94%. The mercury cleaning plant at Tinfos was thoroughly described by Haaland et. al. at Infacon 9 [1].

Eramet: Following Tinfos' experience, Eramet Norway decided to perform pilot tests on mercury removal. Three different Hg cleaning technologies for the raw gas were pilot tested on-line, Lurgi using activated carbon impregnated with elemental sulphur in a packed bed, Boliden-Contec selenium coated spheres in a packed bed, and the Milltec system using a sodium hypochlorite wash-disodium sulphide precipitation. The Lurgi Hg removal unit was selected and consists of an electrostatic precipitator to remove residual dust and tars, a gas heater, a packed bed absorber, a fan-damper system to control the gas flow through the unit and extensive gas analysis-nitrogen purge equipment to maintain low O_2 levels in the gas. The heater is required to warm the gases to the optimum temperature of 60-85^{o}C; lower gas temperatures result in lower reaction rates and moisture condensation in the packed bed, higher temperatures can result in sulphur being lost from the absorbent. The Hg removal unit was commissioned in 2001 and has been trouble free since. Gas flow rates through the unit are around 15,000Nm^3/hour. Hg absorption efficiency is 98% and allowing for plant starts-ups, etc, 94% of the total Hg in the raw gases is captured. Absorber mass is changed after about 8 months operation and is disposed of in a secure land fill. Only trace amounts of Hg report to the scrubber water. In 2003 the SiMn furnace was converted to HCFeMn operation.

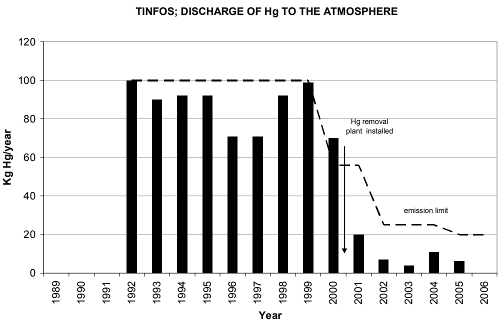

Figure 6: Tinfos Hg to the atmosphere

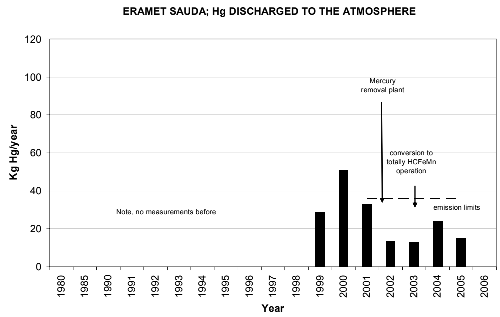

Figure 7: Eramet Sauda Hg to the atmosphere

6.3 Utilisation Of Exhaust Gases

Tinfos: In 1980 Tinfos build a thermal power plant for recovery of energy from the furnace gases. The carbon monoxide and hydrogen rich gas was burned in a boiler to produce steam which powered an electricity producing turbine. After the start up of the power plant one experienced that the remaining dust from the furnaces clogged the surfaces inside the boiler. To solve this problem the washing water in the third venture scrubber was changed to fresh and cold river water. After this action the cleaning of the off-gas was improved significantly. Since 1980 Tinfos has recovered 15% of the electric energy used on the plant.

Eramet: The cleaned raw gases from the Eramet Sauda smelter are partially used for in-plant heating and partially flared. Sauda is considering building a gas powered power plant to recover to energy from the raw gases. Eramet Porsgrunn exports the cleaned raw gas to Yara as a fuel source.

6.4 Utilisation Of Warm Water From The Plant

Tinfos: The start up of the Tinfos thermal power plant gave large amounts seawater heated to 15-20°C. It was obvious that the energy in this water had to be exploited, and since 1983 Tinfos has grown turbot in heated sea water from the thermal plant. At present Tinfos has rented the fish farm to a professional fish farming company producing annually 250 tons of turbot.

Eramet: Sauda uses the cooling water from the furnaces to heat the local football pitch and keep the streets ice-free in winter, and to heat the swimming pool in summer.

6.5 Cleaning Of Suspended Solids From The Discharge Water

Tinfos: Until 1992 Tinfos operated only one sedimentation tank in connection with the cleaning of the off-gas from the furnaces. Since 1993 a second sedimentation tank has been in operation, resulting in much lower emission of suspended solids. Figure 8 illustrates this. It has to be mentioned that when Tinfos increased metal production by 50% in 2000, the emission limits on all matters remained unchanged.

Eramet: In 1990 Eramet Sauda improved the operation of the water-cleaning plant and began recirculating the majority of the scrubber water back to the scrubbers rather than discharging it to the sea. This resulted in a decrease in the discharge of suspended solids to <10% of the previous levels.

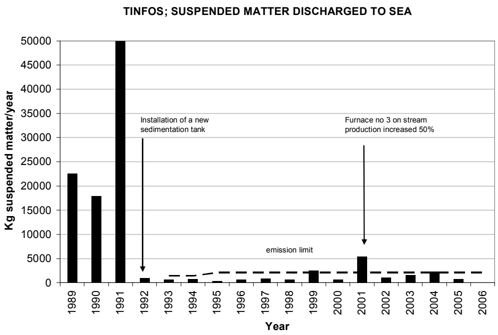

Figure 8: Tinfos; suspended solids discharge to the sea

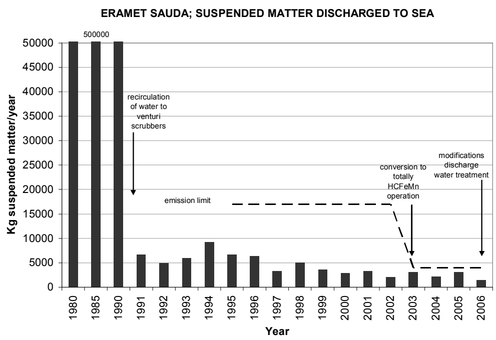

Figure 9: Eramet Sauda; suspended solids discharge to the sea

6.6 Cleaning Of Mn From The Discharge Water

Tinfos: Due to high pH, between 8,5 and 9,0 in the discharged water, no cleaning is necessary. Dissolved manganese is precipitated as hydroxide.

Eramet: Mn discharged to the sea decreased dramatically after the scrubber water was recirculated back to the scrubbers in 1990. Mn discharged began to increase again after 2003 when the SiMn furnace was converted to HCFeMn operation and the consumption of ore increased. In 2006 the water cleaning plant was modified to include chemical treatment for heavy metal precipitation, a lamella thickener and a sand filter. Discharge levels have dropped to <10% of levels immediately prior to the modifications.

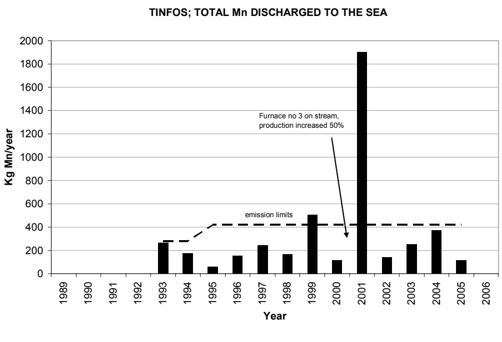

Figure 10: Tinfos Mn discharged to sea

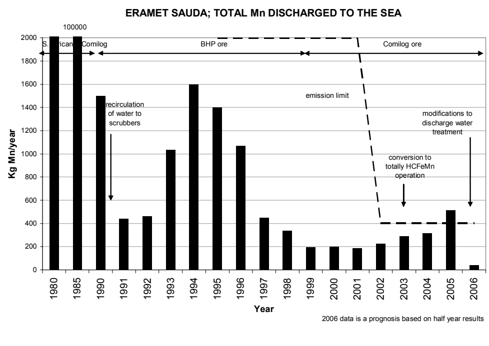

Figure 11: Eramet Sauda Mn discharged to sea

6.7 Cleaning Of Zinc From The Discharge Water

Tinfos: As for manganese, high pH in the scrubber water precipitates zinc as zinc-hydroxide.

Eramet: Dissolved zinc discharged to the sea has steadily decreased over the years. However 2003 and 2004 saw an increase in Zn discharged when Sauda became a HCFeMn operation and the consumption of Comilog ore increased. In 2006 Sauda began treating the discharge water to precipitate zinc as the hydroxide. Soluble zinc in the discharge water has dropped to <10% of the pre-treatment levels

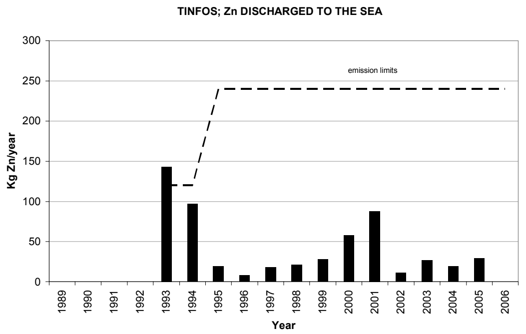

Figure 12: Tinfos Zn discharged to sea

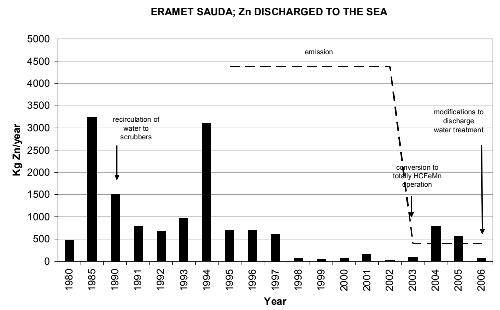

Figure 13: Eramet Zn discharged to sea

6.8 Cleaning Of Heavy Metals From The Discharge Water

Tinfos: As for manganese and zinc, high pH gives precipitation of heavy metals as hydroxides.

Eramet: The change over from HCFeMn-SiMn operation to only HCFeMn operation in 2005 resulted in an increase in the discharge of heavy metals to the sea. In 2006 the water cleaning plant was modified to include chemical treatment for heavy metal precipitation, a lamella thickener and a sand filter, and this has reduced the discharge to below the levels experience before the conversion to a total HCFeMn operation.

6.9 Cleaning PAH From The Discharge Water

Tinfos: As previous mentioned in connection with the operation of the thermal power plant, Tinfos changed to river water in venture scrubber no 3. The river water flowed direct to the fjord from the scrubber. Technically this worked well, but increased levels of PAH in the fjord were detected. The PAH originated from the third venture scrubber stage. Thus, a PAH cleaning plant was erected in 1991. The main cleaning steps consist of sand filter and an active coal filter. The sand filter removes suspended solids before the water is either recirculated to the venturi scrubber, or it is sent to the active coal filter for removing of PAH before it is discharged to the sea. For better performance of the third venturi scrubber the recirculated water is cooled in a plate cooler before it re-enters the scrubber. Analyses of discharged water show that the PAH cleaning plant has reduced the emissions by 99,86%.

Eramet: The installation of a sand filter and an activated charcoal filter in 2006 has reduced the PAH emissions to <30% of the pre-filter level.

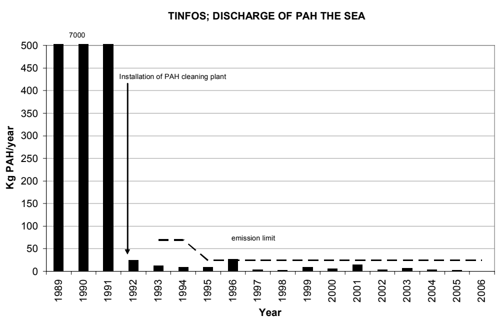

Figure 14: Tinfos PAH discharged to sea

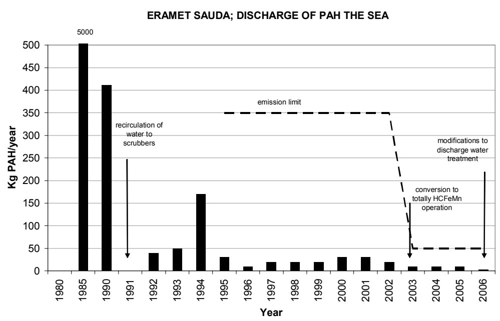

Figure 15: Eramet PAH discharge to sea

6.10 Noise Pollution

Tinfos: To reduce noise from the crushers and power screens, equipment has been shielded by sand barriers. Feeders and hoppers have been built in with roofs and walls. A lot of effort has been put into noise reduction on fans, and specially designed dampers have reduced the noise level with 10 dBA or more. Investments in new front end loaders from Volvo and Komatsu have proven to be a success as a noise reducing measure.

New legislation from Norwegian authorities on noise in the vicinity of living areas gives strict levels; 50 dBA during day time, and 40 dBA during night time.

Eramet: The smelter has many close neighbours and has therefore focused on reducing noise from the crushers and power screens by totally enclosing them in sound-proofed buildings. Fans have been like wise clad in sound deadening materials and the exhaust stacks have been fitted with mufflers. Transportation of materials around the plant is restricted during nights and weekends discharge.

7. CONCLUSIONS

In terms of technology and competence, the Norwegian ferroalloy industry is among the leaders in the environmental field. This presentation summarize the environmental improvements made by two Norwegian manganese producers during the last three decades, both in terms of process improvements and installation of state of the art pollution control equipment. Even though the effluents have been reduced substantially there must still be an intense focus on further improvements, both on internal and external environment.

This is a subject Norwegian producers have to address seriously if they want to continue their operations and likewise it is hoped that smelters worldwide adopt similar environmental standards and invest in corrective procedures.

Table 4: Effluent data Tinfos

TINFOS													
year	suspended solids to sea		Mn to sea		Zn to sea		PAH to sea		Hg to atmosphere		Dust to atmosphere	
	kgs/y	limit kgs/y	kgs/y	limit kgs/y	kgs/y	limit kgs/y	kgs/y	limit kgs/y	kgs/y	limit kgs/y	kg/year	limit kgs/y
1989	22537						7000					
1990	17833						7000					
1991	49994						7000					
1992	918						25				33100	
1993	610	1402	265	280	143	120	13	70	90	100	33100	
1994	719	1402	177	280	97	120	9	70	92	100	36100	
1995	355	2099	57	420	19	240	9	24	92	100	34200	
1996	683	2099	153	420	8	240	27	24	71	100	28500	
1997	880	2099	245	420	18	240	4	24	71	100	20600	
1998	704	2099	164	420	21	240	3	24	92	100	20000	
1999	2497	2099	507	420	28	240	10	24	99	100	22000	
2000	642	2099	113	420	58	240	6	24	70	56	15000	
2001	5442	2099	1902	420	88	240	15	24	20	56	19800	
2002	1077	2099	142	420	11	240	4	24	7	25	15900	
2003	1587	2099	252	420	27	240	7	24	4	25	12100	
2004	2252	2099	372	420	19	240	4	24	11	25	13400	
2005	763	2099	113	420	29	240	3	24	6	20	11300	
2006		2099		420		240		24		20		

Table 5: Effluent data Eramet Sauda

ERAMET SAUDA												
	Suspended solids to sea		Mn to sea		Dissolved Zn to sea		PAH to sea		Hg to atmosphere		Dust to atmosphere	
Year	kg/y	limit (kg/y)	(kg/y)	limit(kg/y)	(kg/y)	limit(kg/y)	(kg/y)	limit (kg/y)	(kg/y)	Limit (kg/y)	(kg/y)	Limit (kg/y)
1980	568191		11433		468							
1985	475000		99300		3250		4787					
1990	61595		1500		1514		412					
1991	6654		442		788		0					
1992	5000		461		681		40		-		50000	
1993	6000		1031		970		50		-		42600	
1994	9200		1600		3100		170		-		50000	
1995	6700	17000	1400	2000	700	4380	30	350	-		45000	
1996	6349	17000	1070	2000	714	4380	10	350	-		60000	
1997	3311	17000	449	2000	618	4380	20	350	-		60000	
1998	5076	17000	338	2000	60	4380	20	350	-		30000	
1999	3651	17000	195	2000	54	4380	20	350	29,0		60000	
2000	2975	17000	197	2000	76	4380	30	350	51,0		40000	
2001	3260	17000	186	2000	165	4380	30	350	33,0	36	35000	
2002	2115	17000	225	400	27	4380	20	350	13,4	36	28800	
2003	3121	4000	290	400	81	400	10	50	13,0	36	43700	35000
2004	2185	4000	319	400	780	400	10	50	24,0	36	30000	35000
2005	3056	4000	514	400	556	400	10	50	15,0	36	20000	35000
2006	1500	4000	43	400	70	400	3	50				

REFERENCES

[1] Bruno,B., Haaland, D., Thomassen T., "Mercury removal from Off-gas at Tinfos Manganese Plant, Øye Smelt-everk;, Infacon 9, pp 430-438.