NORIT POWDERED ACTIVATED CARBON IN FLUE GAS CLEAN UP

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1. Introduction

The preservation of our environment calls for waste incineration and the reuse of limited resources. This includes the remelting of metals. During these processes, pollutants are emitted in the flue gases necessitating a thorough flue gas clean up. Elaborate systems have been developed to remove dust, acid and heavy metals from the flue gases of incinerators. However, the elimination of low concentrations of toxic dioxins/furans, mercury and other trace element contaminants in the vapour phase requires an additional treatment. NORIT has therefore developed special grades of powdered activated carbon (PAC) such as NORIT GL 50, to adsorb both mercury and dioxins/furans together.

NORIT PAC dosing is an extremely economic way of emission control in new or existing flue gas treatment systems. The PAC is blown or sucked into the flue gas stream. The dioxins/furans and/or mercury are adsorbed onto the PAC. In this lecture we will summarise some NORIT experiences of the last 10 years.

2. NORIT activated carbon types

Activated carbon is an adsorbent consisting of small disturbed graphitical crystallites interconnected by amorphous carbon. Activated carbon has a very large internal surface and an unique pore structure created by selective oxidation of graphite layers during activation. For technical applications activated carbon is produced from peat, coconut shells, wood, lignite, coal and olive stones. Activation can be carried out by steam or by chemical activation. By using different raw materials, activation processes and process conditions an optimal pore structure and pore volume can be realised for a large number of applications.

NORIT produces powdered activated carbons (PAC) from a wide range of raw materials and processes. From the different products manufactured, we can choose the most suitable carbon type for a specific application, as was done for flue gas clean up. See for typical characteristics of the NORIT powdered activated carbons for flue gas purification table 1.

2.1. NORIT SA types

From 1986 onwards NORIT SA 3,a powdered activated carbon, has been dosed in the flue gas from a municipal waste incinerator in Switzerland, to remove the toxic components with high efficiency. Later on, SA Super being an extremely active product, has been applied as well (see 3.1) One should keep in mind that these SA type products originally were developed for liquid phase applications and should therefore be considered as sub-optimal for flue gas cleaning purposes.

2.2. NORIT GL 50

Based on this first experience with SA types NORIT developed specific carbon types for flue gas clean up. From the practical experiences it seemed that the main items for a good flue gas clean up carbon type are:

- **Activity/Pore size distribution**

Dioxins and furans are large molecules which require a medium activity powdered activated carbon for its best adsorption capacity. The carbon type may not be to micro porous which prohibits the larger molecules from entering the pores of the activated carbon. That is why NORIT selected a powdered activated carbon with a BET surface area of approximately 800 m^2/g.

- **Particle size distribution**
  The activated carbon particles have to be well distributed in the flue gas. An optimal contact area is needed to adsorb the small amount of dioxins/furans and other components. Therefore NORIT selected an activated carbon with an average diameter of approximately 20 micron.
- **Burning and explosion behaviour**
  Using GL 50 in flue gas applications no risks for explosion and burning arise because during production the raw material is activated at a high temperature with a residence time of several days

2.3. DARCO FGD

At high mercury concentrations adsorption by means of chemisorption is necessary. Chemisorption is considered irreversible. Our non washed lignite based products, such as DARCO FGD contain many sulphur complexes in the pores which can react with mercury, binding it within the pores as mercuric sulphide. Next to mercury chemisorption, benzofurans and dioxins can be adsorbed by physical adsorption.

2.4. New trends in carbon development

Next to municipal waste incinerators there are a number of other waste incinerator facilities. Some of these facilities have to cope with much higher mercury contents than normally present in municipal waste. For these applications special impregnated carbons have been and are developed like GLZ, an activated carbon impregnated with chloride, or an activated carbon impregnated with sulphur. Next to mercury chemisorption, furans and dioxins have to be adsorbed by physical adsorption.

3. Practical experiences and references

NORIT has built up last 5 years a full range of references throughout all types of waste incinerators. NORIT's practical experience is proven by several tests and measurement programs. Some of these references and tests will be presented.

3.1. Municipal waste incinerator, the Netherlands

This incinerator is one of the most sophisticated and largest in Europe[1]. They have installed 4 flue gas treatment lines of each approximately 150,000 Nm^3/h flue gas. They treat in total 2400 metric tons waste per day.

A schematic diagram of the flue gas treatment system is given in figure 1.

The dioxin inlet concentration is in the range of 0.6 to 2.3 ng TEQ/Nm^3.
Two types of powdered activated carbon are used:

- *NORIT GL 50* is dosed just before the spray absorber in order to remove the dioxins/furans from the flue gas. In the start up phase this incineration company optimised their system to get the dioxin content as low as possible. It became obvious that due to the set up of the system and the high starting amount of dioxins/furans the scrubber lining adsorbed significant quantities of dioxins/furans. The adsorbed dioxins/furans were desorbed by the lining material after decreasing the dioxins/furans emissions into the system. Therefore the total dioxins/furans emission in the stack was influenced.
- *NORIT SA Super* is added to the scrubber flow in order to remove dioxins/furans from the water phase. The dioxins/furans contents of the carbon are in the order 50ng/g

NORIT SA Super. The total removal efficiency over spray absorber and scrubber is 90 to 95%. In the end the stack emission reached an average value of 0.05 TEQng/Nm^3.

3.2. Municipal waste incinerator, Germany

This municipal waste incinerator utilizes NORIT GL 50 for the removal of dioxins/furans and mercury in their flue gas treatment installation. This installation is in use since 1994.

Three lines, treating 1080 tons of waste per day, are available in this facility. A schematic diagram of the flue gas treatment system is given in figure 2.

The NORIT GL 50 is dosed without any other additives. The spent PAC is burnt completely in a separate muffle furnace, resulting in almost no additional waste. The flue gases from this mufflefurnace are treated by the existing flue gas clean up system. The dioxins/furans are burnt completely, the mercury evaporates and is removed by the scrubber. No extra emission of mercury is noticable in the stack.

3.3. Field studies of flue gas treatment using NORIT PAC

Developments in the United States of America have resulted in some field tests with NORIT PAC[2,3,4,5]. These field tests have been performed under auspices of the EPA (Environmental Protection Agency).

In the USA the removal of mercury from flue gases is the main purpose of the injection of PAC. Dioxins/furans are, in contrast with Europe, of less importance. Therefore these tests are mainly performed to determine the removal efficiency of PAC for mercury. Table 2 shows the removal efficiency for mercury and dioxins. The efficiency for mercury removal is between 70 and 85%, for dioxins values between 96 and 99% are found.

4. Safety characteristics

The DMT Gesellschaft in Dortmund, Germany, performed measurements according to VDI 2263 to examine the burning and explosion characteristics of NORIT GL 50. At contact with a hot surface smouldering of stationary activated carbon dust layers does not takes place up to 450^{0}C. Interpretation of the auto-ignition temperature data indicates that at 200^{0}C no ignition takes place in carbon volumes smaller than 0.05m^3. For storage of 100 m^3 carbon the temperature must be lower than 110^{0}C. So storage of GL 50 in silo's is without risks. The lower explosion limit in air is 125 g/m^3 at 20^{0}C and 30 g/m^3 at 200^{0}C. A typical dosing rate for GL 50 is about 50 mg/Nm^3. At a recirculation number of 25 the maximum PAC concentration will be about 1.25 g/Nm^3.

5. PAC dosing and storage

To a great extent, the rate of activated carbon consumption will determine the size and type of handling system required. Small users could take delivery in (big) bags while larger users will probably have preference for delivery in bulk trucks.

The design of dosing systems for injection of the activated carbon into the flue gas stream varies with the method selected. If the carbon is to be injected as a slurry, a mix tank with an agitator will be required. Metering systems for slurries are relatively simple in design and produce accurate dosing rates. Dry powder handling systems require the addition of a dosing hopper which accommodates typically 4 to 24 hours consumption. Metering can be done volumetrically by a proportional rate screw feeder or by weight displacement using load cells.

6. Conclusions

- From our experience in the clean up of flue gases we can conclude that NORIT has specific powdered activated carbon types suitable for the removal of dioxins/furans and heavy metals.
- The removal efficiency is 90 to 99% for dioxins/furans dependent of the flue gas clean-up system.
- Dosing of NORIT PAC in several kinds of flue gas clean up systems has proven the ability of achieving removal efficiencies far beyond the severest emissions requirements. Spent PAC can be burnt in the incinerator for a clean disposal of the product.
- As proven under operational conditions and by independent laboratory investigations, NORIT PAC can be used safely in the flue gas clean up of waste incinerators. With several kinds of dosing and storage facilities, a total solution for the removal of dioxins/furans and heavy metals can be supplied.

7. Literature

1) Sierhuis, W.M., Vries, C. de, Born, J.P.G.: Chemosphere vol 32 No 1 pp 159-168, 1995
2) GVRD faculty, Burnaby, BC. Operated by Montenay Inc. Data presented by Terrance L. Guest and Ota Knizek at the Air and Waste Management Association, June 1991.
3) Stanislaus County, NJ. Operated by Ogden Martin Systems of Stanislaus. EPA research and development report, EPA-600/R-92-192. September 1992.
4) Camden County, NJ. Owned and operated by Camden County Energy Recovery Associates, a division of Foster Wheeler Power Systems. EPA research and development report, EPA-600/R-93-181. September 1993.
5) Status of EPA regulatory development program for medical waste incinerators-results of emission test program. May 1992.

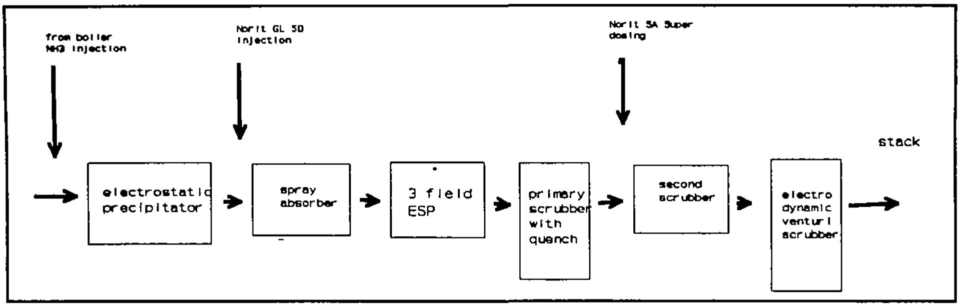

Figure 1. Schematic diagram of minicipal waste incenator, The Netherlands

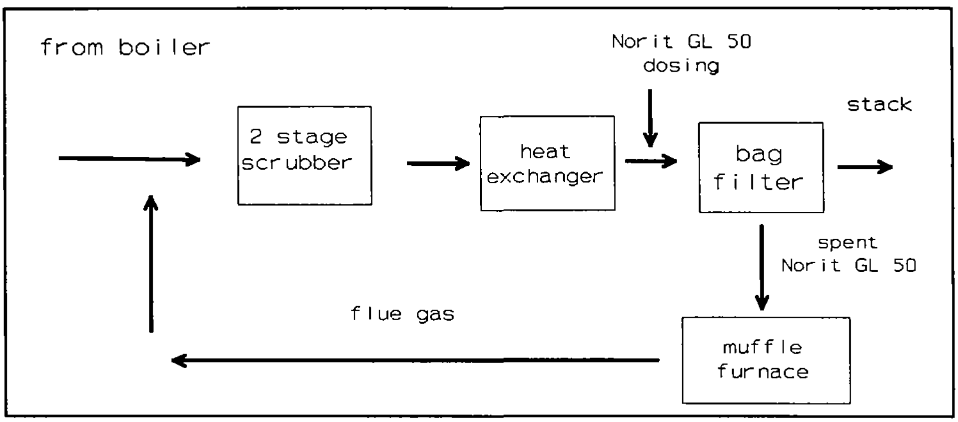

Figure 2. Municipal waste incinerator, Germany

Table 1. Typical analysis of NORIT powdered activated carbons for flue gas treatment

	NORIT SA 3	NORIT SA 5	NORIT GL 50	DARCO FGD
Iodine (mg/g)	800	650	700	500
Apparent density (kg/m^3)	460	520	490	500
Internal surface are (m^2/g)	850	750	800	600
Particle size				
> 150 micron (w/w%)	4	4	3	
> 73.1 micron (w/w%)	20	20	13	
> 44 micron (w/w%)	30	30	28	
> 10 micron (w/w%)	65	65	60	
Grind through 325 mesh (w/w%)				95
Sulfides (w/w%)			0.2	1.5

Table 2. Emission results of field studies in flue gas treatment

site	Burnaby	Stanislaus		Camden							
Type of waste	Municipal	Municipal		Municipal						Medical	
Flow, Nm^3/h	3*33000	2*92000		3*62000						2300	
Injection temperature, °C	140	140		132					176		
Particle collection	bagfilter	bagfilter		electrostatic precipitator						bagfilter	
PAC dosage, mg/Nm^3	40	15	60	40	80	171	362	441	322	116	291
Hg inlet conc., mg/Nm^3	540	644	786	635	800	508	642	715	749	7380	9503
Hg outlet conc., mg/Nm^3	51	104	42	132	169	29	17	12	63	587	389
Hg removal eff., %	91	83.2	94.5	78.1	80.4	94.4	97.3	98.4	92.3	92.0	95.9
dioxins removal eff., %							96.4		96.1	98.6	97.9