U.S.A. TRENDS IN POWER STATION EMISSION CONTROL

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SUMMARY:

At a recent conference in Florida papers were read on methods for the control of emissions of SO_2 and particulates. The review indicates progress which has been made in improving the efficiency of electrostatic precipitators (by design of new electrodes and improved methods of 'cleaning' electrodes) and of preventing loss of fines in bag filters.

OPSOMMING:

By 'n onlangse konferensie te Florida (Amerika) was lang gepraat van metodes om die uitstorting van swawelsuur en stofdeeltjies van die skoorstene van kragstasies te verminder. 'n Oorsig word gegee van sekere navorsingsresultate waarvan gebruik word nou gemaak om uitstorting snelheid drasties te verminder.

The recent Denver Research Institute sponsored "Third symposium on transfer and utilisation of particulate control technology" held in Orlando Florida forms the basis of the following comments. The symposium did not deal exclusively with the control of power station emissions but the bulk of the papers presented did cover various aspects of this topic.

1. *BACKGROUND*

Power stations in the U.S.A. have to meet the following emission requirements:

Particulate emission	<	0,1 lb/million Btu
Opacity of plume	<	20%

Flue-gas desulphurisation if high sulpher coal is used.

Ever more emphasis is being placed on the plume opacity requirements. This emphasis is a reflection of the growing concern over fine particulate emissions which are within the respirable range.

To avoid the expense of flue-gas desulphurisation most power stations prefer to use low sulphur western coals. Fly-ash from this type of coal has typically a high resistivitly and is more difficult to collect efficiently in a precipitator. The control authorities enforce the emission requirements and if need be the power stations are required to derate their capacity to a point where emissions are in compliance. Under derated conditions the generating company is often required to purchase power from the national grid to meet its commitments. For this reason there is often an economic incentive to improve precipitator performance. One plant for example finds it economic to spend \$4 million per annum on flue-gas conditioning agents.

2. *OPTIONS AVAILABLE*

Few of the U.S.A. power stations are mine-mouth situated, and coal is bought on the open market. To be able to meet emission requirements for a variety of coals the available options are:

(a) Uprating and improvement of existing electrofilters
(b) Installation of baghouse
(c) The use of flue-gas conditioning
(d) Flue-gas desulphurisation

3. *UPRATING ELECTROFILTERS*

Historically electrofilters have been the preferred cleaning method. As the fly-ash from western low sulphur coals tends to have a high resistivity a considerable amount of research (apart from increasing the physical size of the units) has been done. Some of the options proposed are as follows:

3.1 *Plate rapping.* Considerable research into the optimum level of plate rapping so as to maximise dust removal and miminise dust re-entrainment has and is being done. One company considers an average acceleration of 50 g at all points of the collector plate to be the optimum.

3.2 *Discharge electrodes.* The U.S.A. has relatively recently moved away from the hanging wire approach in favour of the European rigid frame approach. The actual physical shape of the electrode has been considered important. Desirable properties include:

(a) Suitability to tall systems
(b) Cleaning characteristics similar to collecting electrodes
(c) Enhancement of collection efficiency
(d) High spark-over voltage
(e) Selectable voltage/current characteristics
(f) Robustness

On the basus of these criteria one company reported that a rigid tube with pointed corona emitters attached at specific distances along the length of the tube is the optimum design.

3.3 *Wavy collection electrodes.* A wavy collection electrode has been proposed. The contoured collector results in a near uniform electric field along the electrode. There is an additional advantage that collected material is effectiviey shielded from the main gas flue.

3.4 *Pulse Charging*. This is currently the most favoured route to enhancing precipitator performance. Several papers were offered and considerable work is being done in this field. Some observers feel that whilst it is likely to prove effective the cost of installing and running these units will be similar to the addition of an extra field with the end result being much the same.

3.5 *Pre-charging*. Pre-charging continues to be of interest and the installation at TVA's Bull Run plant is often quoted. Observers seem to feel that the benefits are as yet short lived and would like to see this approach improved.

3.6 *All plate zones*. In an effort to improve the collection of fine particulates a final field of alternately charged plates has been proposed. Encouraging results have been obtained in pilot plants and trial plants.

3.7 *Hotside precipitators*. The U.S.A. would appear to be the only country to use hotside precipitators on any scale. There is now a general consensus that this was a move in the wrong direction. It is doubtful whether any further units will be installed.

4. *BAGFILTERS*

To date bagfilters control emissions from more than 14,000 MW of generating capacity in the U.S.A. Experience has shown that the impact on plume opacity is marked and that the system is insensitive to variations in coal. Bagfilters are economically attractive if the migration rate of the fly-ash is lower than 4 - 5 cm/sec. In regard to energy requirements actual results have shown that provided baghouse pressure-drops are in the 100 mm WG range the overall baghouse power requirements are virtually identical to a precipitator which requires a relatively high electrical input to the T/R sets.

4.1 Actual operating experience of baghouses on fly-ash

4.1.1 *Dust and gas distribution*. As settling of the coarser fractions ($>30\ \mu$) often occurs in the dust prior to the baghouse care must be taken in designing the inlet manifold to ensure even distribution of the particle sizes across the bags. Furthermore acceleration and deceleration of gases within the baghouse should be smooth to avoid eddying.

4.1.2 *Optimum number of compartments*. 10 - 12 compartments are considered optimum in that load spikes are minimised when a compartment is off-line for cleaning whilst allowing optimisation of the cleaning cycle.

4.1.3 *No of bags per compartment*. There are two basic limiting factors these being:

(a) The number of bags which can be replaced by a team of operators during two shifts
(b) The point where the hopper becomes overweight and over-sized.

4.1.4 *Bag cleaning*.

(a) High velocity reverse air flows are undersirable
(b) Warm and not cold reverse air should be in the order of 1,5 - 2 x A cfm/ft^2 of active cloth area in compartment.
(c) Excessive cleaning should be avoided. Experience shows that batch cleaning initiated by a pre-set ΔP level offers a lower overall operating ΔP than when cleaning is on a pre-set time schedule.

4.1.5 *Baghouse pressure drop*. This can be predicted by a simple extension to the Carmen-Kozeny model

$$\Delta P = K_1 A + K_4 \times \frac{A^2 \times t \times DH}{\sqrt{T} \times d^{0,8}}$$

ΔP	=	Pressure drop inches WG
A	=	Air-to-cloth ratio (fpm)
t	=	Time required for a complete cleaning cycle (hours)
D	=	Fly-ash flow rate (grains/acf)
H	=	Site atmospheric pressure inches mercury
T	=	Gas temperature ^{o}R (^{o}F + 460)
d	=	Dust mean particle size (microns)
K_1, K_4		Constants determined from field data

4.1.6 *Bag coatings*. Teflon, due to wetting problems, encapsulates only 35 - 40% of the glass fibres. For this reason, where high sulphur coals or low operating temperatures, or cyclic operation occur, acid resistant coatings such as Q78, acidflex and chemfles, where fibre encapsulating rates are far higher, are used in preference.

4.1.7 *Outages*. For short outages (under two days) the baghouse can be "bottled up" provided the insulation is good (minimum of 3" thick) and hopper heaters are left on.

For longer outages the bags should be cleaned at least six times before unit is brought off line.

4.1.8 *Start-ups*. Baghouse should be by-passed until the internals are over 93°C and several coal mills in operation.

4.1.9 *Boiler tube leaks*. Leaks in the superheater section present no problem provided the baghouse temperature remains above dewpoint.

Large leaks in the economiser section result in water in baghouse and muddy filter cakes. A remedial strategy which has worked was to by-pass off-gases after which the baghouse was "bottled up".

After the boiler had been repaired it was brought on-line via a by-pass until the bags had dried out. A ΔP-initiated by-pass facility should be available.

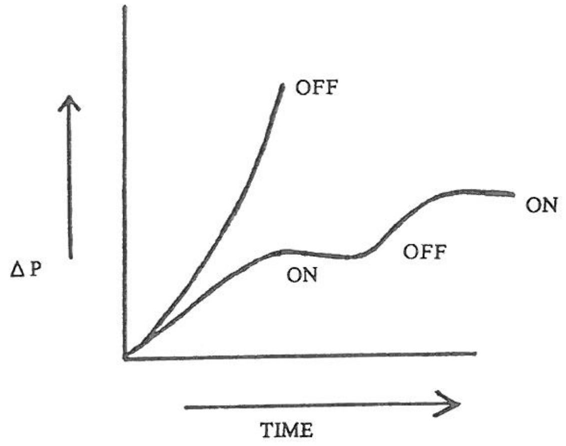

FIGURE 1 – CORONA PRECHARGING
Notes (1) 25 KV charge

4.2 *New developments in baghouse filtration.* Considerable development work in the filtration of fly-ash is being done. Some of these developments are:

4.2.1 *Pre-charging/electrostatic augmentation.* Several papers discussed the effects of pre-charging particles prior to filtration on the use of the bag support cage as an electrostatic grid. In both cases an appreciable reduction in operational pressure drop has been observed; in addition cake release characteristics and reduced particulate escape was also noted. This development holds the promise of smaller, cheaper and improved baghouses for a given application. These effects are shown graphically in figures 1, 2 and 3.

4.2.2 *Filtration cycles.* On reverse air application it has been found that longer filter cycles result in lower overall pressure drop. A possible explanation is that with longer filter cycles the re-entrainment of fine

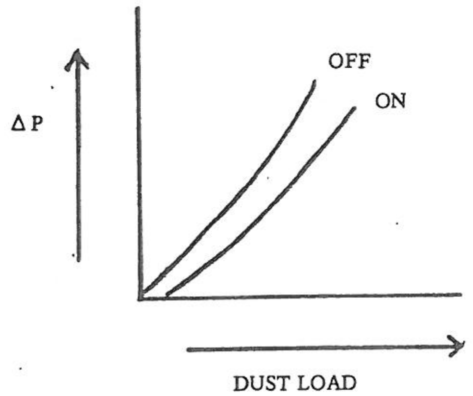

FIGURE 2 – CORONA PRECHARGING
Notes (1) 5 KV/CM charge
(2) Reverse Pulse
(3) Filter time increases by 50%
(4) Penetration only 20%

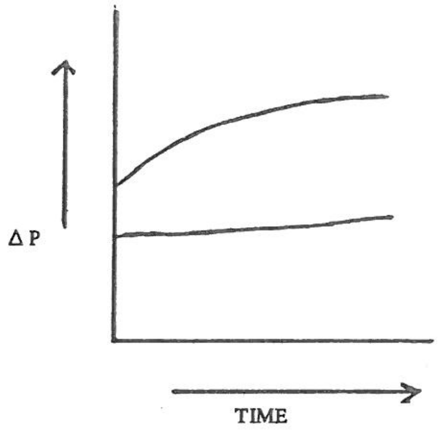

FIGURE 3 – ELECTROSTATIC AUGMENTATION
Notes (1) KV 1 - 5 KV/CM
(2) Current 10 - 100 MA/BAG
(3) Power 0,1 W/FT²
(4) Predicated 40% savings on power costs

dust which occurs during each cleaning cylcle is minimised. Figure 4 shows the results of this EPRI experiment.

4.2.3 *Retention of toxic elements.* As heavier metals tend to be enriched in the fine particulate fraction the fate of these metals is of great interest. The results of one investigation is given below

BAG FILTER RETENTION OF TOXIC TRACE ELEMENTS

Metal	*ppm in coal*	*Ton/annum*	*% Retention in bag filter*
Lead	34,8	24673	63
Arsenic	14,0	9940	91
Cadmium	2,52	1787	55
Selenium	2,08	1475	100
Berylium	1,3	922	77
Mercury	0,2	142	100

EPRI EXPERIMENT

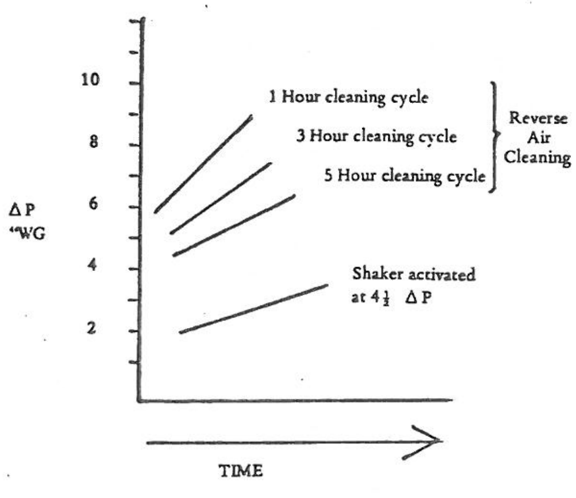

FIGURE 4 – EFFECT OF VARYING FILTER TIMES

5. *FLUE GAS DESULPHURISATION*

Lime based desulphurisation techniques seem to be the most favoured. One company assessed the costs to desulphurise off-gases from a 500 MW boiler. They considered the three most popular lime methods and three different grades of coal. The costs were as follows:

Capital cost	\$ 56 - 110 x 10^6
Running cost	\$ 17 - 27 x 10^6
Electricity	\$ 1,5 - 1,9 x 10^6

Desulphurisation by means of passing a lime slurry through a spray drier with a baghouse downstream is reportedly temperature sensitive and the following figures were quoted:

SO_2 removal efficiency	Spraydrier oF	Baghouse oF
85%	180	175
90%	145	145
98%	145	200

Some observers queried the lime industries' ability to supply sufficient high grade lime and that even if this was possible whether it was wise to allocate such large quantities to the power industry.

Less efficient desulphurisation occurs during filtration in the baghouse where it is reported that between 10% to 40% of SO_2 can be absorbed onto the filter cake, dependent on the alkalinity of the fly-ash.

6. *FLUE GAS CONDITIONING*

Flue gas conditioning offers an alternative method of uprating the efficiency of an existing precipitator.

One method is the injection of SO_3 gas. The SO_3 is generated by passing heated SO_2 which is obtained either as liquid SO_2 or is generated by burning liquid sulphur through a vanadium catalyst. A minimum conversion rate of 87% and an average of 92% is obtained in a single pass through the catalyst. Dosage rates at ± 20 ppm (v/v) successfully reduce fly-ash resistivities to the order of 5 x 10^{10} ohm cm and effective migration rates in the order of 8 cm/sec are achieved. This type of unit is installed on over 100 boilers and works successfully. The sulphur burning approach is favoured above the liquid SO_2 approach, the reason for this being the problem of leakage in the SO_2 transfer lines. During periods when no SO_3 is required the conversion process is stopped and the SO_3 line is purged to avoid possible corrosion. The original problems experienced with SO_3 generating units have been solved by the input of electrical energy into the system to ensure thermodynamic balance rather than relying on the exothermic reaction to supply sufficient heat.

The other major conditioning route is to inject proprietary chemicals into the flue system. Solutions can be injected either before or after the air heaters. Injection prior to the air heaters has resulted in the blockage of the air heaters in certain applications. This system which is low in capital cost has been installed with success at numerous plants.

CONCLUSION

There exists a widespread qualitative awareness of the properties of dust. There is also a feeling that somehow the beginning and the end of life are linked to dust. Most people would however be surprised at the complexity of form and composition to be observed in the microscopic world of dust. The irregular nature of dusts and the importance of their surface properties make it difficult to characterise dusts by means of a few simple parameters such as length or mass. In order to predict the toxicity of a dust or understand how it will be transported in a moving gas stream we must be sure to choose the appropriate parameters to measure and to use the correct instrument for the measurement. If we choose well, the bafflingly irregular world of dust can be made understandable and controlable. Without this understanding we will not be able to say if a stack is 'of sufficient height' or if a pollutant has been 'dispersed effectively'.

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