SOME OBSERVATIONS ON AIR POLLUTION CONTROL AND RESEARCH RELEVANT TO COAL-FIRED POWER PRODUCTION IN THE USA

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SYNOPSIS:

In this presentation a few of the many observations made during a study tour of air pollution control and research activities in the United States are outlined briefly. The discussion should in no way be considered to be exhaustive or to represent either the views of all participants or those of the organisations they represent.

INTRODUCTION

In March 1982 a study tour of power plants and organisations concerned with air pollution in the United States was undertaken by a party of six persons from South Africa representing ESCOM (Messrs L A West and H O Egenes), the Department of Health (Mr P Odendaal) a pollution control company (Mr M Bulley) and the CSIR (Messrs D Heinichen and R G von Gogh). The objectives of the tour were first, to determine the status of and trends in coal-fired power plant gaseous and particulate-matter control, incorporating regulatory practices, technology and research. Secondly information was sought on the methodologies and instrumentation used in environmentally orientated research including dispersion modelling, meteorology and epidemiology. In pursuing these objectives, visits to the institutions, organisations and power plants listed in Table 1 were arranged. The source control techniques of interest were bag filtration and enhanced electrostatic precipitation (ESP) for particulate-matter removal and flue gas desulphurisation (FGD) for the reduction of gaseous sulphur emissions.

SOURCE POLLUTION CONTROL

Marked escalations in the oil price have led to an increasing tendency for utility companies in the US to convert existing boilers to coal-fired operation and to rely on coal for fuelling future power stations. Against the background of stringent emission and ambient pollution standards a quest for progressively more effluent control devices has occurred. The EPA standards of most concern in this regard are the New Source Performance Standards (NSPS) requiring power plants constructed after 1977 to adhere to emission limits of 0.1 lb 10^{-6} Btu and 20% opacity for particulate matter and 0.3 lb 10^{-6} Btu for sulphur dioxide.

The practice of burning low sulphur Western coals to reduce sulphur dioxide emission has led to problems of reduced ESP efficiency and hence non-compliance with particulate matter standards at many plants in the US. Reduced collection efficiencies stem from high fly ash electrical resistivity (approx. 10^{12} ohm cm), a characteristic shared by South African fly ashes. A surge of interest in bag filtration and methods of upgrading ESP performance has resulted in the US.

TABLE 1

Institutes, organisations and power plants visited in the USA

Institutes, etc.	Location
EPA	Research Triangle. Partly NC and Washington DC.
Flakt Inc.	Knoxville, Tenn.
TVA Headquarters	Chattanooga, Tenn.
Florida State University	Talahassee, Fla.
Southern Research Institute	Birmingham, Ala.
Brookhaven National Labs.	New York.
Texas Utility Generating Co.	Dallas, Texas.
Electric Power Research Institute.	San Francisco Calif and Denver, Colo.
Meteorology Research Inc.	Los Angeles.
S. California Edison Co.	Los Angeles.
Wahlco Inc.	Los Angeles.
Power Stations	
Shawnee	Paducah, Kentucky.
TUGCO Big Brown	Dallas Area, Texas.
Monticello	Dallas Area, Texas.
North Valmy	Winnemucca, Nev.
Riverside	Minneapolis, Minn.
Arapahoe	Denver, Colo.
Coyote	Beulah, N. Dak.
Brunners Island	Harrisburg, Penn.
Clay Boswell	Cohasset, Minn.

Bag filtration

In the US bag filtration has come to the fore as an alternative to ESPs where difficult ashes cause problems in the complying with emission standards. A large number of fabric filter installations is in operation and they have been found to perform very efficiently when suitably designed, operated and maintained. Bag houses have been retrofitted and planned for power boilers of up to 500 MW and are multi-compartment with generally low air-to-cloth ratios. Cleaning of bags (generally teflon-coated glass fibre) is most commonly via the reverse (pulsed) air method and bag lives of 2-4 or more years are obtained. Flange-to-flange pressure drops across the bag houses vary between 4 and 10 in. WG depending mainly on cleaning cycles and maintenance standards. Very few installations experience high pressure drop, nodule formation or early bag failure problems but all are subject to widespread and intensive investigation.

Sufficient practical experience has been gained in the US to make bag houses a viable alternative to ESPs. Advantages of bag houses over ESPs include their continously high collection efficiencies (> 99%) for all particle sizes, the ease of on-line maintenance without need to reduce boiler load and their ability to maintain emission standards regardless of variations in coal characteristics. There is also evidence to indicate that trace element and SO_2 capture occurs on the filter cake, thereby reducing such emissions.

The ability of bag filters to retain very fine particles (submicron) which have important effects on visibility and human health should provide strong motivation for their selection over the ESP alternative.

Particulate matter removal in South African power plants is accomplished solely by ESPs (a few very old plants use cyclones) the efficiency enhancement of which is an area of major endeavour in the US pollution control field.

Electrostatic precipitation enhancement

Aside from new designs for TR sets, discharge and collection electrodes and rapping techniques, various means have been developed and use to improve ESP collection efficiencies. Chief amongst these is flue gas conditioning whereby SO_3, ammonium sulphate or proprietary chemicals are injected (before or after the air heater) into the gas upstream of the ESP. Mathematical models and experiments show that better collection seems to be effected more by a reduction of resistivity than by induced particle agglomeration. Given coal and ash analyses as well as boiler operating conditions, the mathematical models have been used to predict, reliably, the improved ESP efficiency. Pure triethylamine conditioning (as used at Kelvin Power Station, Johannesburg) has not been employed, owing to reservations about some of the possible by-product emissions. Interest in the results of local experience with this techniq was however expressed.

Other attempts to improve ESP performance are by mea of revised electrical techniques such as ionisation, pr charging and pulsed charging of the particle-laden g stream. The latter technique is at the most advanced stag of development but detailed evaluations are yet to b carried out on full scale installation.

Microprocessor-based control systems for EPSs are in th initial stages of development and testing and they are pro jected to have significant effects on ESP performance.

Gaseous emission control

Sulphur dioxide and nitrogen oxides are subject to EPA emission standards, the latter being achieved by furnace design criteria. While NSPs demand the installation of the FGD (Flue Gas Desulphurisation) systems to remove at least 70% of SO_2, regardless of coal sulphur content, most utilities still rely on coal selection to achieve compliance with standards. By March 1980, 65 FGD systems had been installed on US utility boilers having a total capacity of 22000 MW, i.e. 10% of the coal-fired generating capacity. This figure is projected to increase by 20% by 1990. Efficiencies of SO_2 removal range from 50% to 90% for the various types of FGD systems, the latter being achieved by the rarely used double alkali technique. The most common FGD system is one whereby the flue gas is reacted with an alkaline slurry containing one or several of the following compounds: limestone, lime, soda ash, sodium hydroxide and magnesium oxide. These systems usually produce a wet waste material presenting gross mass waste removal and storage problems but, in some, gypsum or the primary reagents may be recovered. Scrubbing systems employing spray driers and producing a dry product which may be retained by downstream ESPs or bag houses are in use (< 1% of the market) but require and are receiving further attention to design and development. Much informed opinion, both in research establishments and in the utility industry has it that at present FGD systems should, wherever possible, be avoided!

Alternative approaches to sulphur dioxide emission reduction employed in the US include coal beneficiation (washing), coal switching and environmentally determined emission limitation by episodic load reduction. The latter technique, termed Sulphur Dioxide Emission Limitation (SDEL), was for many years used by coal-fired plants of the Tennessee Valley Authority (TVA), the largest utility company in the US, to control ambient levels of SO_2. This receptor-orientated approach, involving load shedding and redistribution during periods forecast to have meteorological conditions adverse to dispersion, has recently been outlawed by the EPA in pursuance of its source-orientated or emission limitation control policy. While using the approach, the TVA had greatly improved its record of compliance with ambient standards in the vicinity of its plants and at a capital and maintenance cost far less than that for emission control hardware such as FGD.

RESEARCH AND INSTRUMENTATION

Much air pollution-related research in the US is funded and administered by the EPA via contracts, many involving multi-agency cooperation. Fields range from technological research such as low NO_x burners to regional pollution dispersion and characterisation studies. All aspects of power production research including air pollution is carried out by and under the auspices of the Electric Power Research Institute (EPRI). This organisation, through which a prolific amount of high quality research is carried out, derives its funds from a levy on all utility companies for each kilowatt hour of electricity sold to customers. All of the larger utility companies additionally maintain in-house research departments having strong air pollution related components. Additional research organisations include non-profit institutes such as the Southern Research Institute, Stanford Research International and many university departments while many commercial undertakings are active in the air pollution field.

The fields of research in air pollution followed in the US (even those discussed by the tour party) are too numerous and complex to be treated here. It is, however, prudent to mention some avenues of potential significance for the South African situation.

Regional pollution transport and dispersion studies involving many organisations and much modern equipment seem to be the focus of environmentally-related research. Noteworthy is the use of airborne instrumentation which has been developed to a high degree. The total characterisation of emissions and their mechanisms and rates of transformation are considered important, the problem of acid deposition being the sensitive issue that it is.

Pollution dispersion modelling receives widespread attention owing to its use in planning and control strategies and a new, comprehensive series of multiple source regional dispersion models (the COMPLEX suite) is under development for inclusion in the EPA approved UNA MAP model suite.

Remote sensing of pollutants, employing techniques such as LIDAR and COSPEC, is commonly used in air pollution research programmes in the US, the COSPEC technique for SO_2 and NO_x being a well-developed and reliable tool which merits consideration for local applications.

Epidemiological research is central to the establishment of control strategies (including standards setting) and industrial planning. Owing to the great influence of unique factors such as climate, heredity etc. on the human health effects of pollution, such studies should be important components of air pollution research anywhere.

Research into pollution control technologies is, as mentioned, proceeding apace in the US and many publications and detailed reports on findings incorporating every aspect from design to economics are continually being issued. Monitoring of this output and testing on a pilot scale some of the developments would be advisble for relevant parties in South Africa.

SOME OBSERVATIONS ON CONTROL POLICY

The ambient and emission standards enforcement policy embodied in the US Clean Air Act while being administratively cumbersome, is certainly effective (it was enlightening to not be able to see power plant plumes) and is a major spur to ongoing research and development. The practicalities of the system are well known and will not be discussed here. It should be noted that the policy is not static and comes frequently under review as the results of new research become available. Thus revisions to the SO_2 standard and the introduction of a sub-ten micron particulate matter standard (PM10) are under consideration at present. Legal and bureaucratic machinations however, prevent the rapid introduction of new policies and standards, a major drawback to the system!

An interesting observation is that very few power utilities are mine-mouth located, preferring to transport their coal over hundreds and even thousands of kilometers, this being a direct consequence of air pollution control policies. The effect is to distribute more evenly the influence of major emissions.

CONCLUSIONS

The overwhelming impression gained from an examination, in far more detail than can be presented here, of US air pollution control and research practices is that much benefit can accrue locally by maintaining a finger on the pulse of these activities.

American experience of ESP enhancement can and is being implemented locally to deal with problematic fly ash emissions. Likewise, bag filtration technology and operating experience could, with due caution, be of potential benefit to industry and the environment in South Africa where low sulphur, high ash coal is burnt. It would seem that FGD systems are as yet not a viable addition to local control techniques but ongoing development in this field warrants close scrutiny. The SDEL and coal beneficiation techniques would appear to warrant attention should gaseous sulphur emissions become a serious problem locally.

In the field of environmental research, observations in the US have indicated that regional pollution studies using advanced airborne and ground-based instrumentation is the best approach and that epidemiological studies are a necessary adjunct to essential routine monitoring practices.

Continuous monitoring of in-stack concentrations and opacities, mandatory for all major US sources, provide a useful basis for control strategies and should definitely receive consideration for local implementation.