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PULSED ELECTRON BEAM PRECHARGER

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PULSED ELECTRON BEAM PRECHARGER

Technical Progress Report Number Eleven

March 1, 1992 - May 31, 1992

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I. INTRODUCTION AND CURRENT STATUS OF THE PROJECT

We shall first briefly review the motivation for carrying out this project and the experimental approach used. The combustion of low sulfur coal for the purpose of generating electric energy in power plants results in the production of a flue gas containing very high resistivity fly ash. This fly ash is not easily collected by conventional electrostatic precipitators due to the large electric potential difference which develops across the layer of fly ash on the collector plate. If this layer of collected material is allowed to reach a thickness as great as is normally desirable before "rapping" the plates, then the collected fly ash is subject to re-entrainment into the flue gas stream due to back-corona. The back-corona corona problem is described more fully in the next section of this report. This re-entrainment problem can be eliminated through reduction of the voltage applied across the high voltage wires and the grounded plates of the electrostatic precipitator. This is not a good solution to the problem since the charging capability and collection efficiency of the precipitator system are both greatly reduced at the low voltages required to avoid the back-corona problem.

Another approach to solving the problems inherent in collecting high resistivity fly ash in an electrostatic precipitator is to decouple the charging and collecting functions. At FSU an electron beam precharger is employed directly before (upstream in the flue gas pathway) the precipitator. This precharger can be optimized for the charging function while the downstream collector can be optimized for collection of the high-resistivity fly ash. The characteristics of the Mk. III electron beam precharger have been investigated in a prior phase of this research. In that previous work electrons from an ionization zone created by the electron beam were drawn across

the flue gas stream by the application of a constant high potential. The maximum voltage was limited by the onset of sparking or production or production of opposite sign ions in the precharger.

Numerous studies have shown that the precharger approach was an excellent solution to the back-corona problem. The results of this research suggested that even better results should be obtainable provided that the precharger anode potential could be raised above the sparking potential limit. Since it has long been known that short duration potentials exceeding the onset of sparking can be applied to gases without the initiation of spark production, the present research with pulsed anode potentials of short duration (≈ 200 ns) was undertaken. The present research using pulsed anode potentials has been highly successful, and we believe that this success is due to the formation of streamers in the gas stream during the high-potential pulse.

Although the present research has not been concerned with removal of sulfur dioxide from the flue gas stream, it is likely that the streamers created in the pulsed electron beam precharging process would convert this pollutant to sulfides in a condensible vapor form. These condensible products would tend to collect on the fly ash particles and be removed concurrently with the fly ash in the collecting section. The deposited sulfides would reduce the resistivity of the fly ash layer on the collector plates thereby further reducing the back-corona problem. The sulfur dioxide removal efficiency of the pulsed electron beam precharger has not been investigated in the present research, but should certainly be addressed in future research. We are very excited about the possibilities inherent in such future research.

The experimental apparatus and experimental results have been presented in great detail in previous Technical Progress Reports 1 through 8, and the reader should refer to these for the experimental details. An interpretation of the experimental results has been made in Technical Progress Report 9. The project is complete except for completing reporting requirements.

II. CONTRACT PROGRESS DURING QUARTER ELEVEN

The present reporting period falls within an extension period of nine months requested for completing reporting requirements. No scientific progress was made on this project during the present reporting period other than insights gained during report preparation.

III. DIRECTIONS FOR FURTHER RESEARCH

We believe that the greatest advantage of pulsed precharger operation will be found in a study of actual flue gas produced by the combustion of low sulfur coal and subsequently passed through the pulsed precharger. The present device demonstrates the practicality of streamer charging of particulate matter (in particular, fly ash) entrained in a gas stream. Previously, workers at this laboratory had demonstrated (and patented) a similar device which used streamers to convert SO_2 to condensible sulfides -- the pulse energized electron reactor (PEER) device. The triggering electrons in the PEER device were produced by a pulsed corona. The corona was

produced in the vicinity of a wire or rod electrode, surrounded by a concentric grounded pipe electrode. Streamers completely filled the active volume of the reactor, producing very high SO₂ removal efficiency.

The triggering electrons in the present particle precharger device are introduced externally via an electron beam rather than being generated from a pulsed corona wire. The creation of electron avalanches and the resultant streamers are produced by the application of sufficient overvoltage and not from the particular electrode geometry. The SO₂ conversion aspect of streamer processing of flue gas has not been demonstrated in the present precharger device, but there is every reason to expect that it is present. We have simply not had the funds needed to acquire the equipment needed to make SO₂ conversion measurements in the present device. The electrode geometry of the present precharger device does differ from that used in the original PEER device, but it is the existence of streamers in these systems which makes them both similar and effective, and it is not due to the details of electrode geometry.

Fly ash produced from low sulfur coal which is passed through the pulsed E-beam precharger is expected to have a reduced resistivity because sulfides will be produced in the streamers, and SO₃ will be subsequently condensed on the particle surfaces. This should make streamer-processed low sulfur coal fly ash have a resistivity more like that of high sulfur coal fly ash. Under these circumstances, the collector voltage could be increased so that it no longer would serve simply as a collector, but could contribute to additional charging of the particles and give an even lower penetration. This would be possible because high sulfur coal fly ash collected

on the precipitator plates does not exhibit the catastrophic voltage drop leading to back corona formation. Concurrent removal of sulfur in addition to fly ash from the flue gas would be an added benefit.

IV. PERSONNEL

The following is a list of persons who worked on this project. This list does not include support personnel in Physics Department facilities such as machine shops, electronic shops, or in illustrative services.

A. Scientific Investigators

1. Dr. W. Neil Shelton Principal Investigator
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