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Project Summary

U.S./German LIMB Technology Transfer

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This report presents key findings of a program in which the U.S. EPA participated in a program sponsored by the Umweltbundesamt (UBA), the German equivalent of the EPA. The UBA program included retrofitting the 700 MWe Weiher III utility boiler of the Saarbergwerke AG with staged-mixing burners for NOx control, and sorbent injection for SOx control. This program was considerably reduced in scope because of restrictions placed upon the utility by local environmental officials concerning the classification of the fly ash generated in the process. During the limited testing period, SO_2 emissions were reduced 8 to 64% depending on Ca/S molar ratio and other operating conditions. The program originally planned at Weiher was ultimately conducted at the 48 MWe Tiefstack Unit 6 of Hamburgishe Elektrizitats-Werke AG. Moderate levels of SO_2 control were achieved (22% with limestone, and 43% with calcium hydroxide). An analysis of the test results suggests that the use of more reactive sorbents could increase the SO_2 removals to 30% and 60% at a Ca/S ratio of 2, for limestone and calcium hydroxide, respectively.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Control of SO_x emissions by dry sorbent injection into boiler furnaces was extensively explored in the U.S. during the late 1960's and early 1970's with limited success. Typically, SO_x removal efficiencies of 18 to 40% were achieved for a variety of boilers over a wide range of calcium-to-sulfur (Ca/S) molar ratios. At economic Ca/S ratios of 1.3 to 2.0, sulfur capture was typically 20 to 33% respectively. These lower (than expected) removals were attributed to: deadburning of sorbent, and decomposition of the resultant calcium-sulfur complex at high temperatures, and; inadequate mixing (contacting) of the sorbent with the combustion gases These results were not competitive with the high (80 to 90%) SO_x removal efficiencies of wet scrubbers. Consequently, further work with dry sorbents was abandoned around 1973.

More recently, attention refocused on dry sorbent SO_x control, prompted by: (1) a reexamination of reaction chemistry that indicated differences from what was previously accepted; (2) new combustion conditions and mixing patterns that appeared to favor sorbent injection in a manner different than previously employed; (3) a need for low-cost NO_x and SO_x controls to support acid rain control strategies, and; (4) pilot-scale tests that showed improved SO_x capture with more reactive sorbents. The EPA acronym for this low-NO_x/SO_x approach is LIMB (Limestone Injection Multistage Burner). EPA-sponsored development programs were underway, and at the time of this project, significant work was in progress in the Federal Republic of Germany.

In this project, the U.S. EPA participated in a program sponsored by the Umweltbundesamt (UBA), the German equivalent of the EPA. The scope of the UBA program included retrofitting the 700 MWe Weiher III utility boiler of the Saarbergwerke AG with staged-mixing burners for NO_x control, and sorbent injection for SO_x control. The retrofit was performed by L&C Steinmuller GmbH, a major German boiler manufacturer. The program was to be the first full-scale evaluation of LIMB technology and presented a unique opportunity for EPA to participate in the program at relatively modest cost. All data developed in the program would be shared between the Federal Republic of Germany and the United States. EPA's participation was essentially concerned with emissions monitoring and characterization of particulate, slagging and fouling, and determination of gas and particle temperatures which are critical parameters to the successful application of LIMB technology. Additionally, this program would augment on-going EPA-sponsored development programs and design criteria studies, and provide an essential link between EPA pilot- and prototype-scale data and full-scale data in the U.S.-sponsored LIMB development effort. Testing at Weiher III was limited to about 3 days of actual testing, due primarily to severe restrictions by local (German) environmental officials regarding disposition of the modified fly ash, and the boiler owner's concerns about deposits in the electrostatic precipitator (ESP). As a consequence, the planned measurement program for EPA was later performed at the Tiefstack Boiler 6 of Hamburgishe Elektrizitats-Werke.

Summary of Sorbent Injection Tests at Weiher III

Weiher III is a 700 MWe coal-fired unit operated by the German utility Hamburgishe Elektrizitats-Werke AG (HEW). The furnace has two combustion chambers and 24 staged-mixing burners. Twelve burners each are installed in the front and rear walls in three elevations by four burners horizontally. Groups of four burners are each served by one mill, and are supplied with sorbent through an injection system. Sorbent is transported by compressed air.

The results of tests with two burners in 1982 were good enough to recommend equipping all 24 burners of the boiler with sorbent injection. These tests were started after considerable delay, due mainly to the classification of the fly ash as "hazardous waste" by the Landesamt fur Umweltschutz und Wasserwirtschaft - LFU (Office for Environmental Protection).

The baseline tests without sorbent injection were performed in August 1984, to collect data on naturally occurring sulfur capture (due to alkaline material in the coal ash), ash characteristics, and process data for the boiler, air heater, and ESP.

The originally planned program of sorbent injection tests had to be considerably reduced due to the restrictions imposed relative to ash disposal. Abbreviated tests were planned with $CaCO_3$ and $Ca(OH)_2$ at different boiler loads, Ca/S molar ratios, and injection planes. These tests were scheduled to take 3 days for each additive.

After receipt of official approval to conduct the sorbent injection tests in November 1984, the tests were immediately started. The first sorbent used was pulverized limestone. It was observed during the course of these tests that the 4:1 molar ratio required at full boiler load could not be attained. The problem appeared to be related to the ejector design. A maximum flow corresponding to a Ca/S of 2.5 was achievable. However, when the six injection lines were run in parallel for continuous feed to all burners, the maximum possible limestone flow was found to be equivalent to a Ca/S molar ratio of about only 1.4. Full load tests with sorbent to all burners were conducted at molar ratios between 0.5 and 1.4. Due to the reduced rate, there was a wide variation in SO_2 capture results. Those obtained indicated only a general trend. Calcium utilization decreased with increasing molar ratio and was on the order of 10 to 20%. Typical SO_2 captures at full load were in the range of only 8 to 12%, at Ca/S ratios of 0.7 and 1.4 respectively. Limited tests were run at 60% load, and Ca/S ratios of 2.5 and 4.0 were achievable. An improvement in both calcium utilization and SO_2 capture was observed. At Ca/S of 2.5, the calcium utilization was 11% with an SO_2 capture of about 28%. At Ca/S of 4, the calcium utilization was 16%, with an SO_2 capture of 64%. No effects attributable to variation on the injection point (upper or lower burner plane) on the calcium utilization could be ascertained.

After completion of the 3-day tests with limestone, the ESP was inspected. Heavier than normal dust deposits were found on the discharge electrodes an[d] plates in the middle and the final cleanin[g] zones of the ESP. These deposits we[re] sticky, and had a high fines content; i.e[.] 66% of the material was smaller than 8[μ] The material also had high sulfur conten[t] The deposits could not be remove[d] through normal blowing and rapping. Th[e] higher fouling tendency in the middle an[d] final ESP stages was attributed to th[e] higher fines content in these stage[s] resulting from sorbent injection. Thi[s] higher dust loading, and the increase i[n] fly ash resistivity, produced a higher loa[d] on the middle and final ESP stages.

The propagation of deposits on th[e] ESP surfaces, which could not b[e] removed by normal means, was a ke[y] factor in the boiler owner's decision t[o] discontinue further sorbent injectio[n] tests.

The Weiher III operating staff hav[e] meanwhile made several efforts to clea[n] the ESP By switching off paths in th[e] preliminary and middle ESP stages, the[y] have reduced deposits in the final stag[e] areas. A recent inspection of the ES[P] surfaces has shown that there are n[o] deposits left .

The measurement program for EP[A] that was originally scheduled for th[e] Weiher power station was later performe[d] at the HEW Tiefstack power static[n] during November and December 1985.

Summary of Sorbent Injection Tests at Tiefstack

A temporary injection system wa[s] installed by HEW on Boiler 6 to evalua[te] the process. The application of sorbe[nt] injection to Boiler 6 was evaluated by th[e] Energy and Environmental Researc[h] Corporation (EER) as a subcontractor [to] L&C Steinmuller, GmbH, for the U.[S.] EPA. The evaluation involved fie[ld] measurements at Tiefstack durin[g] injection tests and the use of models [of] the sulfation process to aid in th[e] interpretation of the test results. Th[e] objectives of the program were to use th[e] field test results to directly evaluate th[e] effects of sorbent injection on S[O2] emissions and boiler performance, [to] evaluate the valididty of the proce[ss] models, and to use the models to ident[ify] optimum injection paramenters a[nd] estimated maximum SO_2 reductions.

The boiler evaluated in the progra[m,] Tiefstack Unit 6, was constructed in 19[..] by Durr Werke AG. The boiler [is] tangentially fired with low-sulfur bit[u]minous coal. The steam flow co[n]figuration is once-through, with t[he] steam used for electrical generation a[nd] district heating. The maximum rat steam flow is 160,000 kg/hr (352,000 lb/hr) at 783K (950 °F) and 14,000 kPa (2000 psig).

The temporary sorbent injection system was installed and operated by the HEW utility. Sorbent was fed from pneumatic trucks to a small feed hopper inside the boiler house, and then fed into a pneumatic transport line with a rotary feeder and ejector. Air for transport and injection was supplied by a rotary air blower. Injection velocity was varied by changing the transport air flow rate, or by varying the nozzle diameter. Due to limitations of the injection system design, and the use of existing observation ports, sorbent was injected through only one or two nozzles using available ports on the boiler. Injection parameters varied during the test were: (1) number of nozzles (one or two), (2) injection velocity, (3) boiler load, and (4) sorbent type (limestone or hydrated lime).

Reductions of SO_2 obtained during the field test were somewhat lower than anticipated, based on the low quench rate of the boiler. Field measurements confirmed that the injection temperature was near optimum. Subsequent evaluations therefore focused on the dispersion of the sorbent and sorbent reactivity.

The results indicate SO_2 removal rates of 22% and 43% at a Ca/S ratio of 2, with high calcium limestone and a calcitic atmospheric hydrate, respectively. In view of the apparently low quench rate on this unit, these results were considered to be somewhat disappointing. However, evaluation of the data suggests that the results are, in fact, consistent with bench-scale data and with current understanding of process controlling parameters. Temperature measurement on the boiler, supported by heat transfer modeling, confirmed a quench rate of approximately 140K/sec (250°F/sec), and a temperature at the sorbent injection elevation of 1520K (2280°F), which is considered to be close to optimum. Also, contrary to initial expectations, sorbent/flue gas mixing with one and two nozzles had little impact on SO_2 removal rates. The boiler data were found to be relatively insensitive to variations in injection parameters. Additionally, small-scale isothermal model tests indicated adequate sorbent dispersion for all configurations studied. Bench-scale sorbent testing under comparable conditions of injection temperature and quench rate yielded SO_2 capture data close to those obtained on the boiler. These data indicate also that the reactivity of the test sorbents is low compared to other similar commercially available materials. The use of alternate sorbents could be expected to increase SO_2 removal at Tiefstack to approximately 30% and 60% at a Ca/S ratio of 2, for limestone and calcitic atmospheric hydrate, respectively

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The complete report, entitled "U.S./German LIMB Transfer Technology," (Order No. PB 88-195 680/AS; Cost: $12.95, subject to change) will be available only from:
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