Dust Collection at Moss No. 3

A scrubber testing program of several years duration followed a costly effort to obtain satisfactory performance from scrubbers installed when Moss No. 3 preparation plant was built. Equipment now in use would be able to comply with any emission standards presently in effect

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MOSS NO. 3 PREPARATION PLANT was constructed in 1958. It was designed to treat the production from the Moss No. 3 mine complex operating in the Tiller and Jawbone-Tiller split veins at a rate of 1500 tph raw feed. The primary froth flotation circuit, consisting of 48 cells, was an afterthought, and total froth product was added to the centrifuged table product as feed to eight multi-louvre dryers. Secondary froth flotation, consisting of 30 cells, was added in 1965, and its product is combined with the steam coal.

Scrubbers included in original plant design

All of the froth and table product is handled by the eight dryers, with the ¼ × 28M table product representing 54 percent of the material and the 28M × 0 filter product material 46 percent. Load to met coal dryers averages 75 tons per dryer and steam 60 tons per hour. The ¼ × 28M averages six percent moisture and the minus 28M averages 28 percent moisture, for total moisture of 16 percent. The dryers have mechanical dust collectors, which have performed at approximately 94 percent collection efficiency, for recovery of dust. The exhaust fans, moving 64,000 cfm, discharged to atmosphere and testing disclosed a solids loading of 3 to 3.5 grains per cubic foot.

It was recognized that stack emission would create severe problems and the Clinchfield management required the inclusion of scrubbers in the original design. Two impingement type, liquid scrubbing units per dryer were installed, but these never operated satisfactorily. The manufacturer and Clinchfield Coal Co. spent several years and well over a million dollars trying to make them operate, but the impingement screens were easily blocked and attempts to correct the problem were unsuccessful. These units represented a misapplication of equipment and over the years had to be by-passed because of uncontrollable fires in them and the danger of explosion.

Donald Jones has been manager of preparation for Clinchfield Coal Co. operations in Virginia, West Virginia and Kentucky for the past two years. Before that, he worked for Susquehanna Colliers Division of M. A. Hanna Co. for 21 years, serving initially as a mechanical engineer and for several years heading up the company's mechanical and electrical departments. From 1956 until he left the company, he was responsible for the preparation department and for 10 years was also manager of industrial sales.

Test unit installed in 1967

Test models of different types of scrubbers were tried over the past few years with varying results. The large volume through the plant, water consumption, pressure drop (which increases required horsepower), and available mounting room presented major problems. Because of the experiences with the equipment installed when the plant was built, any scrubbers using impingement screens were viewed with a rather jaundiced eye.

In 1967, a full size test model of a Turbulaire scrubber of Western Precipitation was installed on what was considered the dryer with the heaviest loading of fines. Because of construction problems, inlet and discharge ducts were not of the best design and necessitated additional equal area testing in the ducts to assure accurate readings. The inlet duct on the test unit was of sufficient length to assure proper testing, but the final installations have short runs from fan to scrubber. Both the test unit and final installation were equipped with six-ft diam × six ft high stacks, well below the desired 60-ft straight run suggested in all test manuals for a six-ft diam stack.

Scrubber has two sections

The size 64 Turbulaire scrubber is a 12½-ft diam × 32 ft high cylinder with a conical top and a conical hopper on the lower end. The scrubber is divided into two sections, comprising the agglomerator and eliminator sections.

The agglomerator section is in the lower portion of the scrubber and consists of a hopper with liquid bath, the inlet gas passage formed by an inner cylinder with a conical nozzle at the lower end, and a liquid level regulating assembly.

The eliminator section is above the agglomerator assembly and consists of a set of turning vanes and a slurry sump preceding the gas outlet.

In the original test scrubber design, dryer gases at 210° F and a volume of 64,000 cfm (nominal) entered tangentially between the inner cylinder and the outer wall, discharging downward through the conical nozzle at an approximate speed of 110 fps. This jet action forces the dust particles and gas to impinge into the water surface. The treated gas passing out of the water bath causes the water to "froth" up into the inner cylinder and results in almost a complete removal of dust particles from the water.

The gas, containing a small portion of fine dust and water, rises through the turning vanes, and cyclonic action throws the water-laden gas against the side-wall, where it drains into the eliminator sump. The liquid entering the sump passes through weep holes to the bottom cone. A fixed rate of water overflow at the weir and a constant drain from the conical bottom removes the solids to the disposal system.

Because we have a low sulfur coal, the corrosion problem is not excessive at this operation. Accordingly, the Moss No. 3 units are constructed of Cor-ten steel. They are epoxy coated in the outer shell and have 304 stainless in the inner core. Units purchased for other installations have been obtained in solid stainless steel construction.

Pressure change cut drying capacity

Results with the test unit led to the addition of seven more units to complete the Moss No. 3 installation. The first problem encountered after completion was a drastic drop in the gas volume, creating positive pressure in the furnaces, which forced a reduction in drying capacity. The plant has four furnaces serving eight dryers, two dryers to each furnace.

With the test scrubber, any imbalance in volume was automatically compensated. However, when all scrubbers were installed, this was not possible, and the problem became quickly evident. The units were purchased

to a specification of 64,000 cfm at 210° F and 4.5 in. pressure drop. Testing showed a flow rate of 58,100 cfm and a pressure drop of eight in. of water. After discussing the problem with the manufacturer, it was decided to open the normal three-in. wide opening in the orifice to 3.5 in. to provide enough area to maintain flow above 100 fps at the required 64,000 cfm volume.

Another problem encountered was the formation in the bottom cone of a "duck's nest" of impinged solids, which had to be regularly cleaned out or the bottom drain would block completely. This problem appeared to be coupled with the impossibility of maintaining a constant water level in the scrubber or a consistent overflow. Considerable pulsating was observed in the weir overflow and it suggested a varying water level in the inner cone with the probability of varying results.

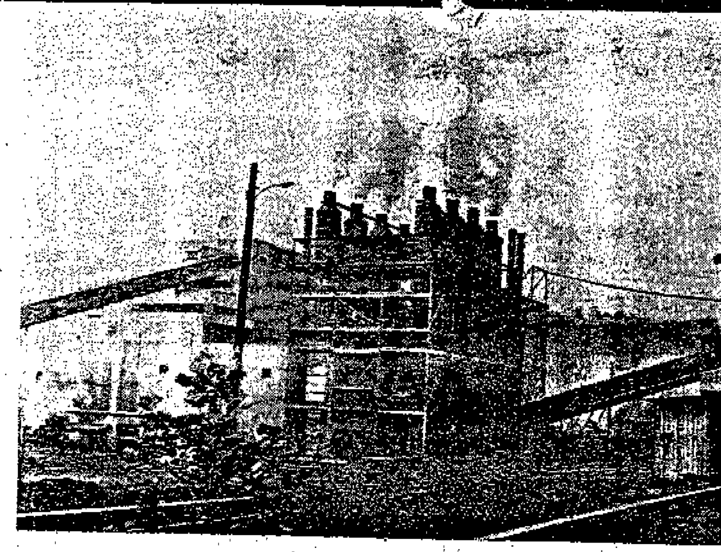
Because of the tangential flow of air, it was obvious that a swirling action was taking place in the bottom cone. To counteract this, it was decided to install baffle plates at the orifice to direct the gases into the bath at right angles to the inlet flow. This prevented the swirling action and also resulted in a "clean bottom," with the only solid buildup noted at the baffle plates. Weir overflow improved and little pulsation was noted. On the basis of this experience, the manufacturer redesigned the scrubber, changing the inlet from a tangential connection to a center inlet. This stopped the swirling action in the scrubber with good weir overflow control.

Water usage greater than expected

One of the inducements of using this scrubber was the low water rate of 85 gpm claimed by the manufacturer for the 65,000 cfm scrubber, or approximately 1-1/3 gal per 1000 cfm. To date, we have not been able to attain anywhere near that figure and the eight scrubbers are presently drawing approximately 1600 gpm. This is a rate of approximately three gal per 1000 cfm. We have hopes of reducing water usage to two gal per 1000 cfm and are slowly working toward that figure.

Currently, we are using "black water" as feed to the scrubber and are discharging the scrubber underflow to our secondary thickeners from where it is reclaimed as feed to the secondary froth circuit. The ash of this material is approximately 12 percent and we are re-

Appearance of stack exhaust from Moss No. 3 preparation plant before, (at left) and after, installation of scrubbers



claiming it at an estimated rate of 150 tpd, with no noticeable buildup in the water circuit or stack emission rate, even though this material is recycled. Screen analysis on the overflow material shows 92 percent through 325 mesh with just a trace of material over 200 mesh.

Loadings average three grains per cubic foot

Various tests have shown loadings going to the scrubbers at 2.5 to 3.5 grains per cubic foot, depending on plant feed sources and operating rates. Three grains per cubic foot represents a fair average over a normal operating period. Particle sizes are extremely small, with 100 percent below 39 micron, 68 percent below five micron, and 10 percent below one micron, as analyzed by the Coulter particle size analysis method.

While there is, and will be, much debate on how accurate our sampling actually is, due to turbulence in the short discharge stack, results to date have been satisfactory as far as we are concerned. When the scrubbers are operating with the correct water level and water rate, there is no noticeable after-trail from the white plume from the stack when observed against a clear sky. When water falls below the ½ in. requirement at the orifice, a brownish haze is noticeable and, if the water level is dropped to three in. low, excessive blow-by will occur and result in a stack emission with an approximate reading of a #2 rating on a Ringelmann chart.

Performance tested on exhaust system

The testing procedure followed is that outlined in a bulletin from Western Precipitation, entitled "Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases." It is similar to the procedure outlined by other manufacturers and worked out in conjunction with engineering societies and federal government agencies.

Since governmental agencies are concerned only with emission, we have confined the major testing to the exhaust stack system only.

The exhaust from the scrubber stack is under approximately 0.2 in. pressure and, in appearance, presents a swirling, boiling, white cloud which plumes out at approximately 50 ft above the stack lip. The air flows through the de-mister, sets up a definite pattern, which lasts well up into the free-plume. We used the equal area method of dividing our stack for testing, using two 3-in. diam test ports set at 90° for inserting a pitot tube.

The stack was divided into four equal area zones and was traversed from the center to the far wall and back to the port in both directions. The velocities and loadings in each zone were tested and, since we were operating with a short stack and changing conditions, many observations were made in each zone in order to provide a control over velocity fluctuations.

Of all the tests run over a recent six-month period, exit gas loading ran:

.0355 *Western Precipitation Field Engineer's Reading*
.0404 " " " " "
.0424 " " " " "
.0360 *Clinchfield Coal Company's Engineer's Reading*
.0480 " " " " "

From these results, we feel this scrubber will provide an emission that will comply with any of the state requirements now in effect.

A test was made by another company of a similar installation at Clinchfield's Compass #2 preparation plant at Dola, W. Va. The company in question has a semi-independent research and development division, which approaches any problem in a strictly scientific, detached way. Their report showed these scrubbers, which we had not attempted to improve at the time of their test, had a concentration of 0.087 grams per standard cubic foot which would exceed West Virginia's code of 0.09 grams per standard cubic foot (110,000 cfm or less) for new installations after March 1, 1970. The testing company assigned an efficiency of 97 percent to this installation. Performance of these scrubbers can undoubtedly be improved by adapting the nozzle opening to maintain +110 fps nozzle speed.

Emissions independent of product moisture

It was noted that dust emission increased during periods of difficulty in furnace operation. Fluctuating dryer load, requiring a reduction in furnace temperature, resulted in a smaller volume through the scrubber nozzle, dropping the nozzle speed below 100 fps, which is the critical speed for impingement in the bath, and increasing the grain loading. Increase in filter cake content of the feed had no effect upon dust emission. There is no correlation between the percentage of fines (-325) in the dryer feed and product and dust emission. Neither is there a relationship between dryer product moisture and dust emission.

Test results of ten readings showed a maximum grain loading of 0.102 grams per standard cubic foot, a minimum of 0.063 and an average of 0.087.

At this time, Clinchfield has installations of this type of scrubber at Moss No. 3 (eight scrubbers), Compass No. 2 (two scrubbers), and Badger (two scrubbers), and two such scrubbers are to be installed at our Kentland plant by Heyl and Patterson.

We are contemplating an experimental installation of a Krebs Medusa scrubber at Moss No. 2 plant. This unit is similar in operating theory to the Turbulaire, but it reverses inlet and outlet direction. We feel that the fan should be at the scrubber discharge instead of the inlet so as to provide a smoother flow through the scrubbers. In this experimental installation, we intend to incorporate all such changes needed to make an ideal installation.

THE REPORT CORNER

Recent Publications of Interest to Mining Men

USGS Bulletin 1272-D. "New Talc Deposit in St. Lawrence County, New York," by C. Ervin Brown.**

USGS Bulletin 1273. "Geology and Mineral Deposits of the San Cristobal District, Villa Martin Province, Potosi, Bolivia," by Herbert S. Jacobson and Carlos Murillo, etc.**

USGS Bulletin 1274-N. "The Chinle (Upper Triassic) and Sundance (Upper Jurassic) Formations in North-Central Colorado," by G. N. Pipiringos, W. J. Hail, Jr., and G. A. Izett. Price: 25 cents.**

USGS Professional Paper 536-C. "Geology of the Coal Hill Hartman, and Clarksville Quadrangles, Johnson County and Vicinity, Arkansas," by E. A. Merewether and Boyd R. Haley.**

USGS Professional Paper 591. "A Descriptive Catalog of Selected Aerial Photographs of Geologic Features in Areas Outside the United States," assembled by Charles R. Warren, Dwight L. Schmidt, Charles S. Denny, and William J. Dale.**

USGS Professional Paper 595. "Geology of Uranium Deposits in the Dripping Spring Quartzite Gila County, Arizona," by Harry C. Granger and Robert B. Raup. Price: $2.25.**

Technical Report. "Computer Applications in Underground Coal Mining," by research team from Virginia Polytechnic Institute. Obtainable from Office of Coal Research, Department of the Interior, Washington, D. C. 20240. Price: $12.00.

Map 1250A. "Geological Map of Canada." Geological Survey of Canada, Ottawa.

Map 1252A. "Mineral Deposits of Canada." Geological Survey of Canada, Ottawa.

Map 2170. "Geological Map of the Sudbury Mining Area." Publications Office of the Department of Mines, Toronto. Price: 75 cents.

Special Report 52B. "Index to Geologic Maps of California, 1961–1964," by James B. Koenig and Edmund W. Kiessling. California Division of Mines and Geology, Ferry Building, San Francisco. Price: $1.75.

Special Report 95. "Talc Deposits of the Southern Death Valley-Kingston Range Region, California," by Lauren A. Wright. California Division of Mines and Geology, Ferry Building, San Francisco. Price: $6.00.

Reprint Series. "An Evaluation of Illinois Coal Reserve Estimates," by J. A. Simon and W. H. Smith. Illinois State Geological Survey, Natural Resources Building, Urbana, Ill. 61801.

Preliminary Interpretation Report. "Airborne Magnetometer Survey of East Central Iowa," Adapted from Report of Airborne Magnetometer Survey of East Central Iowa by Aero Service Corp. Obtainable from Iowa Geological Survey, Iowa City, Iowa.

Geological Survey Report. "Mineral Potential in Proposed Voyageurs National Park in Northern Minnesota." Obtain from Minnesota Geological Survey, University of Minnesota, Minneapolis. 55455. Price: $1.00.

Bulletin 28. "Ground Control in Bedded Formations," by Lawrence Adler and Meng-Cherng Sun. Obtainable from Research Division, Virginia Polytechnic Institute, Blacksburg 24061.

Bulletin 59. "Bibliography and Index of the Geology and Mineral Resources of Washington 1957–1962," by William H. Reichert. Department of Natural Resources, Olympia, Wash. Price: $3.00.

BOOKS

"1968 Year Book." American Bureau of Metal Statistics, 50 Broadway, New York 10004. Price: $5.50 (soft paper covered); $6.00 (hard cloth covered).

"Transactions of Symposium of Mine Taxation." Secretary, College of Mines, University of Arizona, Tucson 85721. Price: $5.00.

** For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.