SMOKE HANDLING IN A LEAD SMELTER

by

F. W. Gibson
Smelter Manager
Missouri Lead Operating Co.
Boss, Missouri

Smoke in General

Smoke is the term commonly used to refer to dust, fume and gas which are natural by-products of all smelting operations. Strictly speaking, the term "gas" should be limited to material which carries no solids or liquids in suspension. "Fume", as differentiated from "dust", refers to material which has been volatilized or sublimed and then condenses as the gases become cooler. "Dust" is any solid particle small enough to be carried by the gas current.

Smoke is produced from three sources in the lead smelting operation:

1. Sintering
2. Blast Furnace Smelting
3. Hygiene Ventilation

Sintering is the process in which the sulfur content of the lead concentrates is burned off, and at the same time the material is agglomerated into porous lumps for feed to the blast furnace. The burning of sulfur is the source of SO_2 gas in the process smoke.

Smelting is the melting and reduction of the sintered material in a furnace, using coke as a fuel and an air blast to support combustion.

Hygiene ventilation is the collection of fume and dust produced at several intermediate stages of both the sintering and smelting operations.

Gases produced in the various operations are eventually discharged into the atmosphere but before this is done it is necessary to:

1. Remove the suspended particulate matter.
2. Cool the gases as much as practical for condensation of fume.
3. Remove or dilute SO_2.

In practice dust and fume are mixed and collected together in a single product commonly called "dust", even though the bulk of the

material is a true fume.

Subsequent treatment of the recovered dust will depend upon the composition of the product. Many smelters have by-product plants incorporated in the operation for recovery of fume values such as cadmium, zinc, selenium, etc.

The principal gases found in lead smelter smoke are nitrogen, water vapor, carbon dioxide and sulfur dioxide. Sulfur dioxide is the only one of these gases which can be harmful to vegetation or cause irritation to humans. It is for this reason that treatment and final disposal of SO_2 is important in smelting operations.

History of Dust and Fume Recovery

In the United States lead was first mined and smelted in 1621 at Falling Creek, Virginia. However, it was not until 1720, at Mine La Motte in southeastern Missouri, that lead smelting was carried out on a commercial basis.

The smelting was done in crude furnaces consisting of enclosed stalls with inclined floors. Galena was charged on top of a wood fire and the melted lead trickled down the inclined hearth and was collected in a basin. This type of furnace operation continued until 1836, when the first Scotch Hearth was introduced from England.

The Scotch Hearth employed an air blast to reduce lead from a charge of Galena and charcoal or fine coal. The hearth furnaces, with various improvements, predominated in smelting lead in the Mississippi Valley of Missouri and Illinois and the tri-state area for the next 80 years.

The hearth furnaces were limited in their application to coarse, clean, high grade lead feed. Therefore, with the discovery of the silver bearing lead deposits in the West between 1865 and 1880 and the limitations of the hearth furnaces, the lead blast furnace came into prominence and has now replaced all other types of lead furnaces in the United States.

In the early days no attempt was made to collect or recover the dust and fume from smelting operations. Hearth furnaces, under the best of conditions, produced large amounts of dust and fume amounting to 25-30% of the ore feed. During the 1860's some smelting plants started use of long flues and settling chambers from the hearths to a single stack in an effort to recover dust and fume.

The first successful fume recovery was accomplished by bag filtering in 1876 at the Lone Elm smelter in Joplin.

By the turn of the century some combination of flue, settling chamber and bag filter arrangement was common on all hearth operations.

Blast furnace operations utilized a flue system only, as the lead content of the charge was low (10-20%) and the furnaces operated with cold tops which resulted in a dust fall of only 2-3% with little or no fume produced.

Bag filtering was used only if the values of the recovered dust and fume would pay for the installation and operating cost of a baghouse.

By 1906 the concentration of lead blast furnaces in urban areas had come to such a point that local laws were passed to restrict emission of fume and dust to the atmosphere. For example, there was a total of 20 blast furnaces operating within a 20 mile radius in the Salt Lake Valley, 10 in Leadville, Colorado and 7 in the city limits of Denver.

As a result, in order to comply with state and local laws as well as to be protected against possilbe damage suits, all the lead smelting plants went to bag filtering of furnace fumes.

About the same time that baghouses were coming into general use for fume recovery, Dr. F. G. Cottrell developed and patented a process for the recovery of fume by means of electrostatic charges, commonly known as the Cottrell process.

The first commerical application of this process was for the recovery of sulfuric acid mist at the Selby smelter in 1906.

The Cottrell process was not limited to handling the relatively chemically inert and cool gases as was the baghouse, but could effectively remove fume from hot corrosive gas. Therefore, it soon became universally used in the copper smelters for the recovery of fume from roaster, reverbs and converters, as well as having widespread use in the recovery of fume from roasting and sintering operations in the lead smelters.

By 1920 the effective recovery of fume and dust in the smelting industry had been accomplished through use of baghouses and Cottrell plants. However, there still remained the problem of sulfur dioxide produced in the roasting and sintering operations. Although dust and fume recovery of over 99% was possible, SO_2 passed freely through baghouses and Cottrell treaters. Most smelters attempted to remedy the SO_2 problem by passing the filtered gas into a common flue and discharging it into the atmosphere through high stacks.

This method of SO_2 abatement was only partially successful as evidenced by the steady increase of smelter stack heights, which increased from 200' in 1910 to over 800' today.

By 1930 a great deal of work had been done on studies for the removal of SO_2 from smelter gases. Many methods were proposed,

but as none were of sufficient commercial value to warrant an elaborate treatment plant, especially from lean gas containing less than two percent SO_2, little progress was made.

The copper smelters at Garfield, Utah; Anaconda, Montana; and Ducktown, Tennessee; started producing limited amounts of sulfuric acid from a portion of the gas for use directly in their plants.

The first production of sulfuric acid from a lead smelter was at the Selby Plant of the American Smelting and Refining Company during the 1940's. This was accomplished by recirculating part of the gas from a down draft sintering machine back through the sinter bed to obtain a gas strength of 4-5% of SO_2. However, in this methods only a relatively small amount of the sulfur burned was recovered as sulfuric acid.

With the development of updraft sintering at Port Pirie, Australia about 1950, it became possible to recover up to 90% of the sulfur burned as sulfuric acid without any recirculation of gas, and the problem of SO_2 emission from lead smelters was well on the way to being solved.

Recovery and Utilization of SO_2

Most lead smelters in the United States dilute the SO_2 gas by combining the cleaned process gases into a common flue and discharging it to the atmosphere through a tall stack. Normally, wind currents will diffuse and dilute the SO_2 content to such an amount so as to be harmless at ground level.

However, with the ever increasing public emphasis on elimination of air pollution, it is apparent that emissions of SO_2 gas and particulate matter to the atmosphere will not be tolerated.

Particulate matter, such as dust and fume in smelter smoke, present no problem as recovery by filtration in baghouses and retreatment of the recovered product are relatively straightforward procedures.

However, the SO_2 in the gas from the sintering operation presents a complex problem. Not only must the SO_2 be removed from the gas, but it must be in the form of a disposable product.

One practical approach, as far as smelter operations are concerned, is to make sulfuric acid from the SO_2-bearing gas produced in the roasting operation. As the roasting of lead concentrates is carried out entirely on sintering machines this type of operation causes several problems in the acid plant; namely, discoloration of the product acid by unburned organic flotation reagents in the concentrate, and the grade or strength of product acid from varying SO_2 concentrations in the gas.

The latter can be controlled, but the discoloration of the acid has restricted the use of acid produced from a sintering operation. Although there are several methods by which the black acid can be partically clarified, none will result in a colorless acid such as is produced from the burning of sulfur, and as a result the only commercial outlet for this acid has been in the fertilizer industry.

In spite of the problems presented, the Amax-Homestake group decided in 1965 that air pollution control was imperative and as a result a sulfuric acid plant was included in the basic design of the new Missouri smelter in order to reduce to a minimum air pollution from SO_2.

The design of the sulfuric acid plant at Missouri Lead Operating Company's smelter is to produce 200 tons of sulfuric acid per day from an updraft lead sintering machine delivering a gas analyzing as follows:

	% Range Vol.
SO_2	4-7
O_2	4-9
CO_2	3-4
N_2	84-85
SO_3	.05-.2
Dust Content	25 grains/scf
Temp.	400^0 - 665^0 F
Moisture Content	25% by Vol.

Vessel sizing; for 25,000 scfm dry gas, with gas cooling system sized to maintain a water balance for the production of 66^0 Be' acid with gas strength of 4% SO_2 at 21,000 scfm.

Acid Plant Operation

Essentially the sulfuric acid process consists of three principal steps:

1. Purification and cooling of the SO_2 laden gas from the sinter machine.

2. Conversion of the purified SO_2 gas to SO_3.

3. Absorption of the SO_3 in sulfuric acid.

The SO_2 gas from the sinter machine contains dust and metallic fume impurities which are removed by filtering the gas through bags in a six compartment baghouse. The hot filtered gas contains excessive water vapor which must be removed by cooling in order to produce a high strength acid. This is accomplished in a tower packed with ceramic rings in which cold weak sulfuric acid is used to scrub the gas passing through the tower.

The cool gas is then passed through an electrostatic precipitator where any remaining fume and dust are removed along with any acid mist. The gas is now optically clear and is passed through a drying tower, where a counter current stream of $66°$ Be' acid removes all of the remaining water vapor.

The clean dry gas leaving the drying tower is then forced through the remainder of the plant by the pressure side of the main blower.

The conversion of the SO_2 in the gas takes place in a converter which is a steel tank containing separated layers of vanadium pentoxide catalyst. The catalyst accelerates the reaction between SO_2 and oxygen to form SO_3.

As the SO_2 is being converted to SO_3 considerable heat is evolved which increases the gas temperature. In order to obtain efficient conversion the temperature range must be controlled carefully. This is accomplished by adjusting the flow of gas through a series of external heat exchangers by means of manually controlled valves.

The SO_2 gas produced in the converter does not combine directly with water, but must be combined indirectly by absorbing it in 98% sulfuric acid. This operation is carried out in the absorbing tower.

The acid in the absorbing tower is strengthened by the absorption of SO_3 while the acid circulating over the drying tower is diluted by the water in the SO_2 gas. Acid strengths are maintained by cross circulation of both acids through their respective pump tanks. The constant transfer of acids containing SO_3 and water increases the amount of acid in the system. The cross flows are adjusted so that this excess acid is maintained at $66°$ Be', which represents the production and is pumped to storage.

Recovery of Dust and Fume

Due to the low sulfur content of a lead blast furnace feed, little or no SO_2 is formed in the smelting operation. Most of the sulfur combines with copper and iron to form a matte or dross with lead bullion or remains in the slag.

The smoke produced in the blast furnace operation consists principally of oxides of lead and some zinc, along with carbon dioxide, nitrogen and water vapor. The dust loading varies considerably depending upon the condition of the blast furnace. Normal dust and fume content is in the range of 0.2 to 5.0 grains/cu.ft. of gas, however, this will increase appreciably if furnace conditions are such that a "blowhole" is formed or the furnace is being operated with a low charge column.

In either case, not only is the dust loading increased but also the temperature of the gas rises, which will exceed 1200° F at times. The temperature is controlled by the addition of cooling air, high pressure water sprays or combination of both. The variations in dust loading and gas volumes are handled more efficiently in a baghouse than in any other type of dust and fume recovery equipment.

Our baghouse is designed to handle not only the smoke from two lead blast furnaces and a dross reverb, but also the hygiene ventilation around these furnaces, as well as the dust produced at the discharge end of the sintering machine and primary crushers. Overall dust and fume recovery is in excess of 99% and there is no visible plume of "flag" from the stack.

The baghouse is a Wheelabrator, two section type, with 7 compartments per section. Each compartment contains 416 bags, 8" diameter x 20' long.

The baghouse has a capacity of 450,000 cfm at 230°F and operates under a pressure of from 2.5 to 6.0 ins water.

Filtering ration with one section out and handling the maximum volume of 450,000 cfm is 2.1 cu. ft. of gas to 1 sq. ft. of cloth area.

Gases from the various sources are combined in a centrally located cooling chamber where they can be cooled to 230° F, if necessary, by means of outside air and a water spray system.

Two Sturtevant 6' x 12' double inlet, draft fans, each rated at 235,00 cfm at 230° F and 12' W.G. move the gas from the cooling chamber to the baghouse. With this arrangement it is possible to operate only one half of the baghouse if conditions allow.

The baghouse operation is fully automatic. Temperature is controlled primarily by the addition of atmospheric air through a damper located in the cooling chamber. A series of high pressure sprays are also installed to supplement the air cooling in cases of extreme temperature.

Shaking of the bags in each compartment for the removal of dust is set on a five minute time interval. A timer actuates the individual inlet dampers and bag shaking mechanism.

Dust is removed from hoppers under each compartment continuously by means of screw conveyors.

In order to reduce dust losses and minimize localized hygiene problems caused by blowing dust, all dust recovered in the baghouses is transported in closed drag conveyors to a 25 ton surge bin. From this bin the dust is then fed into a drum mixer where it is moistened and blended with fine product from the sinter machine.

The preceding has been a general description of the smoke problem in the lead smelting industry and the approach used by the Missouri Lead Operating Company in its solution. This does not mean that there are no other means of treating the smoke problem, but to attempt to cover all phases of smoke handling would require much more time than is presently available.

COMMENTS

QUESTION: On cooling your gases down I think you said you let cool air in and in addition you have a method of spring houses to help cool this gas. How did you handle the water moisture content in the gases? Did this go directly into the bag chamber?

ANSWER: Normally yes. Now one of the reasons we use air for cooling is that you can get yourself in trouble using a lot of water and get condensation in the bag house, sticking of the bags and such. We prefer to go in with a big bag house with the additional cost to build it, using air as a prime coolant---backed up only when necessary with the use of water.