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A study of the losses occurring in the milling and smelting of Missouri-Kansas zinc ores

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T H E S I S

for the

D E G R E E

of

E N G I N E E R O F M I N E S

T 2 2 9

-SUBJECT-

A STUDY OF THE LOSSES OCCURRING
IN THE MILLING AND SMELTING OF MISSOURI-
KANSAS ZINC ORES.

-BY-

Horace Tharp Mann

1910.

Approved: *Durward Copeland.*

10932

The production of Spelter during the year 1908 was as follows: (Mineral Industry vol. 17 pg. 842)

MO-KANS-OKLA FIELD--	123499	tons	of	2000#
UNITED STATES	210511	"	"	"
WORLD	724347	metric	tons.	

From the above it is seen that the United States produced 26.37% of the worlds supply. The out put of the Missouri-- Kansas - Oklahoma Field or what is commonly known as the Joplin District was 58.66% of the zinc produced in the United States or 15.47% of the total out put for the world.

This question naturally presents itself, to produce 123499 short tons or 246998000 pounds of spelter how many pounds of zinc were taken from the ground?

To say the least the literature on the subject of mining, milling and metallurgical losses occurring during the treatment of zinc ores is very meager.

-MINING-

At the present time the greater portion of the zinc mined in the Joplin District, is taken from what is known as the sheet-ground. What percentage of the zinc bearing rock is extracted ~~ore~~^{or}, what percentage is left in the ground when the mine is abandoned, which owing to caving and other causes can not be recovered at some future time, is not known.

It is to be hoped that the State Geological Survey will in the near future be able to take up the investigation of this subject. Until they do it will be impossible to make a reliable estimate on the percentage of the zinc extracted from the ground.

-MILLING-

To obtain a satisfactory statement of the losses suffered during the milling of the low grade ores of this district, will require a long series of experiments at the plants operating on these ores.

It is customary to speak of the grade of the ore by the yield of zinc concentrate per ton.--Thus when

they speak of a 3 1/2 % ore they mean an ore which will yield seventy pounds of zinc concentrate, which will contain about 58 to 60 % zinc, per ton of 2000 pounds, not an ore which contains seventy pounds of zinc per ton of 2000 pounds. This point makes it almost impossible to obtain accurate information, from the published accounts of milling operations in the district.

Reviewing the methods of milling employed in the district a person is led to believe that the losses must be large, some of the reasons for which are as follows:

First. It seems to be the policy of the district to crowd the capacity of the mill to its utmost limit, and ~~even~~ to ^{greatly} overload the machines.

Second. The methods of handling fines and ~~slimes~~ seems to be inadequate in many of the mills, especially in those of older construction.

Third. The system of crushing impresses a person as being at fault in that they attempt to crush to such a fine condition, namely about 3/8 inch before beginning concentration. Some experiments which are being carried on in the laboratories of this school

at the present time, on ore from the Joplin District, seem to show that it would be profitable to begin concentration on material which will pass thru a screen, ~~leaving~~^{having} openings one inch in diameter. These conditions- the overloading of the machines, the inadequate means for handling fines and slimes, and the fine crushing all tend to increase the loss occurring during concentration but to what extent this loss goes it is impossible to state authoritatively.

The loss during concentration is generally estimated at from 30 to 40 % of the zinc content of the ore with an average of about 35 % , but this is only an estimation.

It is probably true that the present method of milling seems to produce the maximum profit per ton of ore treated. It is a question for the future to decide whether other methods, which will save a greater percentage of the zinc that is in the ore, will be more profitable than present methods. There is no questioning the fact that the vast accumulation^s of tailing in the district contain thousands of tons of zinc which have been lost during treatment.

-ROASTING-

In roasting the zinc concentrate there are two ways in which losses occur:

- 1 By volatilization
- 2 By a loss of dust.

(1) The loss by volatilization is due to the higher heat required to completely disulphurize the zinc sulphide it being found necessary to roast so that the sulphur remaining in combination with the zinc, lead and iron is very small, usually not over one percent. This requires a high finishing heat with the result that some zinc is lost by volatilization, part of it as zinc oxide and zinc sulphide, they being slightly volatile at the temperature reached and part of it as metallic zinc which is reduced from the oxide by the carbon monoxide in the furnace gases. There is practically no loss by volatilization when the temperature is below 900 degrees "C", but the temperature at which the roast is finished is usually above this.

(2). The loss by dust is due to the fact that the ore must be crushed so that the maximum size is about

1/6 inch in order to roast.

In crushing an ore so that the maximum size is 1/6 inch a considerable quantity of dust is made. In roasting, the ore must be stirred so as to expose all particles to the action of the hot gases ~~and air~~. This stirring in combination with the draft which is necessary to remove the sulphur fumes and provide the required amount of air for oxidation will carry more or less dust, depending on the velocity of the draft. This dust can only be saved at a considerable expense for the construction of settling chambers or bag houses.

The total loss by these agencies seems to be practically the same in hand roasters as in mechanically rabbled furnaces. It will usually amount to about 1.5 % of the zinc charged to the furnace.

-DISTILLATION-

The ore, having been roasted, is mixed with an excess of carbonaceous material, over that required to reduce the zinc oxide. This carbonaceous material is usually coal. The ordinary mixture consists of about 50% of each, altho the proportions may vary between the limits of 70% zinc ore, and 30% coal to 70% of coal and 30% of zinc ore depending on the grade and character of both the zinc ore and coal.

The retorts, which are usually 8" to 9" inside diameter and 48" to 50" long, are filled with the above mixture. The condenser is then luted on and the firing of the furnace begins.

The heat is gradually raised until shortly before the end of the distillation is reached the temperature inside of the furnace will be about 1200 to 1300 °C, and the temperature inside of the retort possibly a hundred degrees less.

It requires 24 hours to complete the reduction of the zinc oxide and the volatilization of the zinc.

During the distillation the zinc is ladled from the ^{Condenser} ~~retort~~ three times.

When the distillation has reached the point where for commercial reasons it is not practical to carry it further the last zinc is ladled from the condenser, the condenser is then removed and the residue is taken from the retort.

The losses occurring during the operation are as follows.:

1. Imperfect condensation of the zinc vapor.
2. Absorption of zinc by the retort.
3. Escape of zinc vapor thru the walls of the retort.
4. Volatilization of zinc thru cracks in the retort.
5. Zinc vapor lost by being retained in the retort at the end of the operation.
6. Zinc retained in the residue.

These losses will be taken up in the order given.

(I) There are several factors which influence the condensation of the zinc vapor, the principal factors

being as follows:

(a) The temperature of the condenser and the percentage of zinc vapor in the gas entering the condenser.

(b) The percentage of carbon dioxide in the gas entering the condenser.

It has been found from practical operations, that the best temperature for the condensation of zinc vapor is between 450° and 550 °C.

If the temperature of the condenser is too high, the zinc will, to a great extent, fail to condense. No condensation taking place if the temperature rises to 930 °C. This we should expect if we examine the vapor tension of zinc at these higher temperatures, and remembering that the portion of the condenser not occupied by molten zinc is saturated with zinc vapor.

If at a certain temperature a space be saturated with zinc vapor, no zinc will condense unless the temperature be lowered, always presuming that the pressure remains constant. Regardless of the temperature, the gas issuing from the condenser will always be saturated with zinc vapor provided there is enough

zinc coming from the retort to saturate this gas. The pressure remaining constant the amount on percentage of zinc vapor in the gas is determined by the temperature, the higher the temperature the more zinc vapor a definite quantity of gas can carry.

If the temperature of the condenser is too low the zinc will be deposited as a blue powder, which must be ^{re}treated. This blue powder is very finely divided metallic zinc and its formation is, according to Prof. J. W. Richards, analogous to the formation of frost from the atmosphere.

If, for some reason, there is a large percentage of carbon dioxide present, say 0.5 to 1.0%, the zinc will be deposited as a blue powder which must be retreated, or it may escape from the condenser and be lost.

From the information at hand, the loss due to the escape of zinc vapor from the condenser seems to be about 1.5 to 2.5%, with an average of about 2% of the zinc charged to the retort.

(2) When the old retorts are taken from the furnace analysis shows that they contain from 5 to 18%

of zinc. This absorption is governed to some extent by the character of the retort, whether it is dense or porous, and by the materials used in its construction. The greater part of the absorption seems to take place during the first week of the retort's life. The first day the amount of zinc recovered may vary from practically none to 25% of the zinc in the charge, the greater part of this loss is due to absorption by the retort, while by the seventh day the loss by absorption will only be 2 to 3% of the zinc in the charge.

(3) The loss due to the escape of zinc vapor thru the walls of the retort is governed to some extent by the method of firing the furnace. The ordinary coal fired furnaces uses a natural draft - This draft creates a suction which acts on the walls of the retort with the result that the loss is greater than in gas fired furnaces, where there is a slight pressure or in coal fired furnaces, which have a forced draft. Even with the best conditions there is a loss thru the retort walls which, from the best data obtainable, seems to be about 2 to 2.5% of the zinc content of the charge.

(4) The daily breakage of retorts in the Missouri-Kansas Field appears to be about 2 to 3% and even as high as 4%. When it is discovered that a retort is broken, the charge is at once removed. Even with the closest watching there is bound to be some loss, but to what extent it is impossible to state, There being no record of this loss which have been able to find. It is probably figured as loss thru the walls of the retort.

(5) When all of the zinc has been distilled from the charge which it is commercially practical to distill the condenser is removed. As the residue now occupies less than half of the space in the retort there is bound to be some zinc vapor left in the retort, there not being sufficient movement of the gas to carry the zinc to the condenser. This is of course lost, but as it amounts to a very small portion of the losses suffered, no record is obtainable of the percentage.

(6) When all of the zinc has been obtained which it is commercially profitable to extract the condenser is removed and the residue discharged.

MSR The percentage of zinc in this residue will vary from about 4 to 18% and will average about 80 to 12% or about 5 to 8% of the total amount of zinc in the charge. This is due to a number of causes, some of which are as follows:

(a) Presence of sulphur in the ore.

(b) The formation of slags.

(c) Defective distillation.

(a) It has been found in practice that each pound of sulphur in the ore, which is in combination with the zinc, lead, or iron will keep two pounds of zinc from being volatilized. The sulphur in combination with the calcium and barium does not cause the retention of zinc, but the sulphur in the coal will prevent zinc from being volatilized.

(b) If the charge placed in the retort contains certain elements, they at the temperature attained, during distillation will form slags, such as lead silicate, calcium, iron and manganese silicates, and so on.

These slags will, when formed, retain zinc oxide in two ways namely by absorbing zinc oxide and by coating ^{les} particulates of zinc oxide so that they do not have a chance to come into contact with the reducing agent. In the same way the high temperature attained in distillation with the aid of the carbon present will reduce the metals themselves and these metals will mechanically retain more or less zinc.

(c) It has been found that it is not practical from a commercial standpoint to expell all of the zinc. The reasons for this are that it would require too much time and too much reducing agent. So that at the close of the operation there is always more or less zinc in the residues which could have been expelled had enough reducing agent and time been used. This loss is probably the greatest single loss suffered in the smelting of zinc ores.

The entire losses suffered during distillation vary from 10% to 20% of the zinc charged to the retort with an average loss probably much nearer to 20% than to 10%, Placing the loss at 17%, which seems to be a fair

figure, there must be 2410 pounds of zinc charged to the retort to produce 2000 pounds of spelter.

Now tabulating the various losses as enumerated we have:

Loss during milling = 35% of values mined.

Loss during roasting = 1 1/2 % of ore charged to roaster.

Loss during distillation = 17% of ore charged to retort.

So that to produce 2000 pounds of spelter there must be taken from the ground 3934 pounds of zinc.

The losses in pounds of zinc are divided as follows:

Milling - - - - - 1477 pounds.

Roasting - - - - - 47 "

Distillation - - - - 410 "

This means that only about 51% of the zinc which is taken from the ground, ever reaches the market

the balance or 49%, being lost during the various milling and metallurgical operations.