

## SMELTING WITH CRUDE PETROLEUM\*

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The investigations recorded in the following thesis apply principally to a general problem in metallurgy, namely, the elimination of sulphur dioxide and the control of flue dust in the smelting of base metal ores; but they also include the examination of a new furnace by which it is hoped this problem is to be solved, to determine its adaptability for this and other purposes as will appear later.

The two products of the present day smelter, sulphur dioxide and flue dust, have of late excited wide attention chiefly because of their deleterious effect upon vegetation and cattle in the vicinity of reduction plants and also because their production causes considerable loss to the operators themselves. Various plans have been suggested to control the flue dust losses and of these the "bag houses" seem to have met with the greatest success, although even this installation presents many objectionable features; but as yet no one has succeeded in eliminating the sulphur dioxide fumes.

**Process.**—The process used in this series of experiments was suggested by J. Heslewood and his son Wm. Heslewood, the inventors. Extended investigations with a somewhat similar furnace were carried on at Herault, California, and a brief description of the methods of operation and results obtained follows:

The ore is both desulphurized and smelted in one double compartment shaft furnace so arranged that after desulphurization has been carried to the desired point in the upper compartment the ore is dropped to the lower compartment and there smelted. Crude oil fuel is used for the double purpose of supplying heat and an important chemical reagent—hydrogen. Steam is admitted to both compartments to control the temperature in the desulphurizing zone and to furnish hydrogen and oxygen in both zones. The resulting furnace atmosphere is decidedly reducing; its nature being determined by the relative amounts of oil, steam and air admitted. The product passing from the desulphurizing into the smelting zone ranges from 6 per cent. to 8 per cent. sulphur.

The smelted products are slag to be rejected and a matte to be later converted. The passage of gases through the charge is due to a vacuum draught generated by a water-jet pump consisting of a centrifugal pump discharging through an especially designed vacuum chamber into a tank as shown in the illustration. Here all solid particles and substances which are condensed at this temperature are precipitated as the gases rise through the water. This solid material will be largely sulphur and unburned carbon, while the true gaseous products consist chiefly of carbon dioxide, some carbon monoxide, a perceptible percentage of hydrogen sulphide, a trace of sulphur dioxide and a small amount of sulphur carbon compounds, such as carbon di-sulphide.

The experimental observations upon which the foregoing statements are based follow with the chemical reactions which seem to most nearly explain them.

**Preliminary experiments.**—The first experiment was performed for the purpose of determining approximately to what degree hydrogen sulphide and sulphur

dioxide united at various temperatures to give sulphur and water.

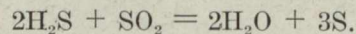
Hydrogen sulphide was generated by the action of hydrochloric acid on ferrous sulphide in a flask having three stopcocks; one leading to the atmosphere; one for the admission of acid and one in the tube passing into the combustion chamber, the latter being the only outlet open while the experiment was running. This gas was passed up through a large bottle containing wet, broken brick to remove any free sulphur which might be present.

Sulphur dioxide was generated in a similar flask by the action of hot, concentrated sulphuric acid upon metallic copper.

Both gases were dried through calcium chloride tubes, since water was looked for as an end product, and then led through a porcelain tube, referred to as the combustion chamber, one inch in diameter, which was heated by a series of bunsen burners. This combustion chamber was cemented with plaster of paris to a water jacketed condensing tube, through which the gases passed into the atmosphere after the possible precipitation of their content had been accomplished.

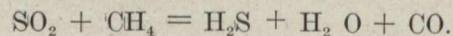
The results obtained were all that could be desired. Precipitation of sulphur and water started while the gases were at a comparatively low temperature, approximately 300 deg. C., and increased in amount until at a dull red heat, water was dripping from the end of the condenser, and a thick shell of elastic, amorphous sulphur had formed within. At this point during the first trial the amount of sulphur dioxide escaping had been very considerably reduced and the hydrogen sulphide had been practically eliminated, only a very faint trace being obtainable with lead acetate. It was evident, however, throughout this experiment, that an excess of sulphur dioxide was being generated. But a later run reversed these conditions and the sulphur dioxide was so reduced that the gases could be inhaled with no serious discomfort. Methyl orange, however, in a faintly alkaline solution, gradually changed color when subjected to the gases, indicating the presence of some small percentage of sulphur dioxide.

The equation representing the reaction occurring in this experiment is:



This experiment indicates that it is possible to reduce sulphur dioxide to free sulphur with hydrogen sulphide, and the method of supplying this reagent was the next point investigated.

Various possibilities present themselves. For example, assuming crude oil to be used as fuel, we have present a variety of hydrocarbons of which methane,  $\text{CH}_4$ , may be taken as a type, and a very probable reaction is indicated as follows:



The reduction of sulphur dioxide by means of hydrocarbon gases has been accomplished by other investigators, among whom might be mentioned Dr. Gotchalt of the United States Bureau of Mines.

\*From the California Derrick, July 10, 1915.