

In our search for a suitable reduction scheme we desired to confine our attention to dry processes in order to avoid the apparently insuperable difficulties attendant upon all wet methods. When it is remembered that the weekly production of ore from Broken Hill mines amounts to some 20,000 tons, and that the maximum density of zinc sulphate liquors practically allowable cannot reach much over 20 p.c., the task of dealing with the huge necessary bulks of solution, and of leaching, filtration, concentration, and precipitation, operations on such becomes appalling. Even then (electrolysis being as yet unsuccessful with aqueous zinc solutions) the result is only a product requiring dry distillation. Indeed, it becomes evident that the difficulties of wet recovery processes only really commence when the solution of zinc or other metal has been effected.

Dry processes are of course no novelty, as witness the efforts of the Smelting Corporation, of Ellershausen, Armstrong, Angel, Claus, and many others in this direction. But we believe we are correct in saying that hitherto all dry processes have started with the intention of recovering the lead and silver in the first instance, whilst obtaining the zinc as a volatilization, or as a slag, or other residual product, for subsequent re-treatment. We cannot, however, include in this category the recently introduced Phoenix process, which, if alone from the daring ingenuity displayed, is worthy of a class to itself.

In fact, zinc has always been considered as the objectionable element in the ore, and the efforts of inventors have almost invariably been towards its early elimination, with the hope, never yet realised, of a subsequent economic recovery. The reasons for this attitude are easy to discern; these ores have always been considered primarily as *lead* ores, whilst those interested in the zinc industry, who may have directed attention towards such, have condemned them at once as unsuitable for treatment in zinc retort furnaces, owing to the fatal presence of lead in any product obtainable by dressing.

The difficulties in distilling leady zinc ores are shortly these. Foremost comes the destruction of the retorts by the reduced lead; this occurring mainly during the stirring out of the seconds from the pots whereby the metallic lead is oxidised to litharge, with the inevitable result of the rapid slagging up and holing of the retorts. Even could this be overcome, it is found in ordinary practice that lead tends to volatilise with the metallic zinc vapours in such quantities as to materially damage the spelter produced. Finally, if lead were capable of complete elimination from the ore, we should still have the question of the silver to deal with, which, as we have shown, largely follows the blende, and would, in the usual routine, be lost both in the seconds and (similar to the lead) by partial volatilisation in zinc vapours.

We may point out that gold also escapes under such conditions, and it was in regard to the recovery of this metal from zinc precipitates obtained from the cyanide process that we were led to devise a method for obviating such losses.* Indeed, the success of this method induced us to further apply the same principles to the treatment of complex sulphide ores. Our idea was therefore to treat these primarily as *zinc* rather than as *lead* ores; and to obviate the difficulties encountered when the material is so considered.

It is necessary to draw particular attention to the rule invariably adhered to in zinc smelting, viz.:—To employ nothing except anthracite as mixing coal; it being supposed that the gases resulting from the carbonisation of other classes of fuel cause losses in spelter. Moreover, other fuels are (reasonably) considered likely to lead to the slagging of retorts during distillation,† a danger to be avoided as far as possible; even good (roasted) blende ores always contain much slag material (Fe_2O_3 , FeS , SiO_2 , etc.), whose baneful influence it is

sought to reduce to a minimum by the addition of a very large excess of coal over and above that required for reduction purposes; such excess acting as a mechanical diluent. As the amount of mixing coal used in general practice varies from 50 to 100 p.c. (on the roasted ore), it is essential that this should contain the least possible ash. Further, slagging troubles would be far more pronounced if an ordinary zinc distillation of roasted Broken Hill ore were attempted; as, apart from the lead and ferrous sulphides, we have also the maganous oxide, which yields a very fluid slag with silica, and much garnet. As the result, however, of our experience in the distillation of zinc-gold material, we formed the opinion that the use of a strongly coking coal would, by holding dangerous materials suspended in its pores, overcome the objections to the presence of lead and other slag formers, and permit of the distillation of complex blende-galena ores as ordinary spelter-yielding material. In this factor alone has lain our main departure from previous methods, and extended practical trials have proved our anticipations correct. It is unnecessary here to further trace our progressive trials, and we now consider the completed process.

It commences with the usual preliminary roast of the crushed ore, slimes, or zinc-lead concentrate, in a reverberatory furnace, to a product which shall contain, preferably, not more than 3 p.c. of total residual sulphur.

The roasted ore is next mixed with only about 20 p.c. of crushed *coking* coal, and the mixture briquetted in any suitable type of machine. As a binding agent pitch, or other carbonaceous material, is added: lime or other chemical binders are undesirable as they tend to permeate the whole briquette with slagging material, and also, from some unexplained reason, to cause lead losses. Further, the admixture of a carbonaceous bond aids the bituminous coal in forming the coherent coke which not only the distillation but the subsequent lead-smelting operations demand. The briquetting plant is of a standard type consisting of a disintegrator, into which the roasted ore, coking coal, and pitch, are introduced, a pug-mill, press and table, together with the usual intermediate elevators and a conveyor belt for delivering the finished briquettes to the retort house.

The briquettes are then submitted to distillation in an ordinary zinc retort-furnace. Those used by us at the Emu works in South Wales are of the old-fashioned hand-fired Welsh-Belgian pattern, without regenerators, and using hand-made pots. Each contains 144 retorts in 6 rows, the lowest being cannon pots: a retort takes about 15 briquettes, the total capacity of a furnace being seven tons.

This type of furnace is, nevertheless, not the most suitable for our requirements, as six rows of retorts one above the other cannot be uniformly heated by bottom firing. The lower row of cannons is apt to be damaged by excessive heat if the uppermost rows are to receive an adequate temperature; too sharp a heat is also detrimental to the best extraction. In most spelter works employing this type of furnace the difficulty is avoided by using the lower rows for the distillation of "hard" material (roasted blende), whilst the upper are employed for "soft" (calamine) ores. On uniform material such as we treat a compromise must be effected; we therefore work to obtain the best results from the three intermediate rows. These give us a 70 p.c. zinc recovery on 26 p.c. briquetted ore, whilst the lower and upper rows yield a few per cent. less.

For these reasons the gas-fired 3-row type of furnace has been adopted for our process at Cockle Creek, as it permits of absolute uniformity of heating, and, therefore, of the maximum recovery. Hydraulic-pressed retorts, so universally used on the Continent and in America, are also employed in Australia. In ordinary zinc-smelting practice the roasted ore and anthracite duff are hand-mixed in front of each furnace, the damped power being then charged into the retort; by our method the mixing is more efficiently performed in the briquetting

*See Journ. Soc. Chem. Ind. xvi. p. 967, also Trans. Inst. Min. Eng., March 20th, 1898.

†Louis and Schnabel II. 89.