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BLAST FURNACE TAR AND AMMONIA.

PROF. N. W. LORD, OF THE OHIO STATE UNIVERSITY.

The utilization of valuable substances which are formed incidentally in any process of manufacture and which have been allowed to waste is one of the great achievements of chemistry. It is to two such materials which are now being lost in enormous quantities in our iron furnaces, though the processes by which they can be saved are known and extensively used in Scotland, that I wish to call attention.

Tar obtained from coal in gas works has a growing value; its price has gone from two or three dollars a barrel to four or five, and the supply in this country is now below the demand, even at these figures. Aside from its chemical value as a source of our most brilliant colors, best disinfectants, and timber preservatives, to say nothing of its being the source of the picrates which are used in some powerful modern explosives, it is more and more used as a roofing and paving material.

The demand for ammonia for all sorts of purposes has run the price up steadily for the last year. The growing use of ice machines for all sorts of refrigerators causes a part of this increase in consumption, but there is a great and ever present market for all forms of ammonia salts, when they can be supplied at a reasonable price, in the fertilizer industries. The absolute necessity of supplying nitrogen to the soil to make up for the constant drain made upon its reserves in this element by crops is shown by the rapid exhaustion of soils in many places and by the growing market for nitrogenous fertilizers all over the world. Our present source of ammonia in America is almost exclusively the liquor of gas works, the multiplying of electric lighting plants, the invention and adoption of new modes of gas manufacture, which completely convert all the fuel into gas, but in consequent destruction of all the tar and ammonia, promise a future diminution rather than extension of this source of supply.

These facts must drive us to the consideration of the two other coal industries before which the manufacture of illuminating gas sinks into insignificance, and which could furnish any quantity of these valuable by-products; these are coke manufacturing and the blast furnace. The improved methods of coking by which all the gas from the ovens is purified and its

tar and ammonia saved are used with increasing favor in Germany, where the value of these products add considerably to the profit on the coal. The ovens are more expensive than the ordinary American bee-hive oven, but hardly enough so to stand in the way of their introduction. A battery of 60-otto ovens is estimated by Lunge to cost an average of about \$1,500 each, including the whole condensing plant for ammonia and tar, ammonia works, etc. Now such a battery of ovens would coke about 60,000 to 65,000 tons of coal a year, and would produce about 1,000 tons of tar and 300 tons of sulphate of ammonia. The value of these products would be at present prices about \$40,000, which even after deducting the extra cost for working, would seem a sufficiently large amount to leave a good margin of profit.

But this question of coke ovens and the saving of the enormous wastes of the crude methods we employ, can be left for the present. The other source of tar and ammonia is the iron blast furnace. This subject is of peculiar interest to Ohio because we have coals which can be used raw in the furnace, and it is only these raw coal furnaces that are interested in the subject of blast-furnace tar and ammonia. The coke furnaces, while they undoubtedly give off a little ammonia in their gases, do not furnish any amount of tar worth considering, but our raw coal furnaces, using as they do, enormous amounts of fuel, a large portion of which simply wastes, are especially interested in knowing what has been done in the way of saving these valuable materials.

The main home of the industry is the west of Scotland. There they use the Scotch splint coals, high in volatile matter and low in fixed carbon and are more cementing or dry. The value of the tar and ammonia which is driven out of the top of the furnace using such a fuel in its raw state is very great. Experience at the Gartsheim works, which were the first to fully equip and push to successful operation a complete plant for saving these valuable by-products show that they save from each ton of coal used in the furnace from 22 to 23 lbs. of sulphate of ammonia and about 40 gallons of raw or 16 gallons of "boiled tar" the value of this amount would be at present market prices about \$1.80 or enough to pay for the coal! Now this is no visionary matter but actual fact. The Scotch furnace companies after having once seen the possibility of economizing in this way jumped at this chance and while in 1881 the first plant was started, in 1889 over half the raw coal furnaces in Scotland were thus saving their tar and ammonia. Now,

why is the industry not considered in this country? In the first place there are but few localities where there exist the conditions for its development. The "raw coal furnace" cannot be moved far from the coal bed, the actual consumption of fuel is too large to stand any bill of transportation. Three tons of coal to a ton of iron cannot pay the freight, hence the locations where such condensing plants and tar works would be possible are few and far between. In the second place, the undertaking seems large and costly and savors of meddling with a business which is foreign to iron makers. Then the furnace men don't know about it or understand it, and so we, situated in one of these localities where the business would flourish under the best form, are losing it seems to me a golden harvest.

The Ohio furnace coals compare as follows with the Scotch splint coals:

COAL FROM	Gortsberrie, Scot-land.	Langloan, Scot-land.	Big Vein, Hock-ing Valley.	Brier Hill Coal.	Jackson Coal.	Upper Freeport, Salineville.
Carbon	70.05	70.04	72.55	78.99	73.48	72.62
Hydrogen	5.24	4.96	4.87	5.65	4.52	4.80
Oxygen.....	12.08	8.57	10.34	9.30	10.50	7.45
Nitrogen	1.36	1.39	1.22	1.58	1.40	1.23
Ash	3.80	5.20	7.30	1.45	0.77	8.10
Sulphur	0.75	0.78	0.57	0.56	0.68	3.00
Water	6.72	9.06	2.95	2.47	8.65	2.80

PROXIMATE ANALYSES.

	<i>Average</i>	<i>Scotch.</i>				
Water		8.	8.90	5.91	9.40	2.80
Volatile Combustible.		35.	36.40	35.01	39.80	36.30
Fixed Carbon.....		52.	48.50	55.70	46.20	52.80
Ash		5.	6.20	3.38	4.60	8.10

The proximate analyses were of different samples except in case of Salineville coal. The ultimate analyses of this Brier Hill and Jackson were from the report of Dr. Wormley and were evidently selected samples. The analyses of the Salineville and the Hocking Valley coal were made by the writer—the Hocking coal was air dried previous to the ultimate analysis which accounts for the low figure for water.

The correspondence shows the general similarity of composition. Daily experience in our gas works shows the general fact that these coals when coked or distilled yield amounts of tar and ammonia which are quite similar to those yielded by the Scotch coals.

The yield in tar and ammonia of the Hocking coal used at the Columbus gas works is $15\frac{1}{2}$ pounds of ammonium sulphate and 12 gallons of tar to the ton of coal. This may serve as an approximate estimate of the furnace yield, though the experience of the Scotch furnace is that the yield in the furnace is decidedly higher, especially in ammonia, than in the retort of a gas works, the furnace yield being as before stated, 22 to 23 lbs. of sulphate per ton, while the retort yield was only 19.7 lbs. The general rule is given by Mr. Jones of Langloan Iron Works that 16 per cent. of the total nitrogen in this coal will be recovered as sulphate of ammonia.

The Hocking coal will average, according to several determinations I have made, at least 1.2 per cent. of nitrogen; by this rule there should be yielded in the furnace .23 per cent. of ammonia or 0.92 per cent. sulphate of ammonia; this means 18.4 lbs. to the ton of coal which should be recovered from the furnace gases. I believe that this result is below what would be realized, but even at this figure the products obtained from one furnace may be estimated as follows:

I have some old figures for Gore furnace, making about 40 tons of iron a day, using 2.69 net tons of coal per net ton of iron. This means 108 tons of coal in 24 hours, which, at 18.4 lbs. sulphate of ammonia per ton, would yield 1,987 2-10 lbs.; tar at 16 gals. "boiled tar" to the ton, 1,728 gallons, or about 43 barrels of tar. This means at present rates—tar at \$4.50—\$64.50; ammonia at \$3.15 per 100 lbs., \$62.50: \$127.00, or over a dollar a ton on the coal used!

Again, let it be said, these are not imaginary figures, but facts undergoing daily demonstration at the iron works of Scotland where it is stated in a recent article on this subject that the saving of these valuable by-products is going to lower the cost of iron ten shillings per ton.

So much for the possibilities. Now how is it done? The difficulties of this problem were so great as to discourage the

early experimenters. The volume of pot gas escaping from the top of a blast furnace is enormous. It may be accurately calculated, however, from the analysis of the gas. I have analyzed the gases from one of our furnaces using raw coal, and find that they run as follows:

COMPOSITION BY WEIGHT.

Carbonic acid.....	8.39
Carbonic oxide.....	33.00
Hydrocarbons.....	2.61
Nitrogen.....	56.00
	<hr/>
	100.00

This represents the average of six analyses. The furnace was using a little coke at the time. Its charge was:

Coal.....	1.75
Coke	0.47
Ore	1.47
Scrap and cinder.....	0.51
Limestone	0.98

per 100 of iron made.

The gas from this furnace would be about $8\frac{1}{4}$ tons to the ton of iron; or, as the furnace was making about 40 net tons a day, there was about 330 tons of gas a day. This corresponds to about $13\frac{1}{2}$ tons an hour, or a ton every 4.4 minutes. Now a ton of "furnace gas," which is about as heavy as air, will equal 28,000 cubic feet at ordinary temperatures, or double that at the temperature it leaves the furnace, so that the actual output is 52,000 cubic feet every 4.4 minutes, or about 12,000 cubic feet per minute, moving in an ordinary "down comer pipe" with a velocity of something like 30 feet a second.

This simple statement shows at once that no simple device will serve the purpose of condensing the tar and ammonia. I mention this fact as I have had submitted for my inspection, a small arrangement for tar condensation which was evidently planned in total ignorance, or neglect of the difficulties of the problem.

The methods in use for the treatment of furnace gas are founded on two different principles, that one cools the gasses, washes them with water, and then treats them precisely as the gas is treated, in this ordinary washing works of a gas works; this plan received the tar and ammonia very fully, and is the one that is in use at the Gortsberrie works. It has the disadvantage of a high first cost but does its work very promptly.

The other process is the acid or hot washing process, and while not cooling the gas so perfectly, pass it through brick lined towers, having water running through them and then into lead lined tanks where it is sprayed with dilute sulphuric acid.

The cost of these plants and the extra work of course is the important item from a commercial standpoint. We can only judge by the results in Scotland where this rapid spread of the process has certainly proved its value.

The cost of the Gortshene plant is estimated at \$25,000 to each furnace and the extra cost for labor at \$2,500 a year, but these figures were given early in the development of this industry and probably represent considerable investment in "experience." The "acid process" is much less expensive in cost of plant, and yields the ammonia very completely but does not so fully separate the tar.

The object of this paper is more to suggest a problem than to fully answer it. The matter seems of great importance, and as the material for its solution is easily obtained, one or two questions of a practical nature may arise: 1st, as to the effect upon the furnace gas of this elaborate washing, will it injure them for heating purposes? This can be easily disposed of by the stated experiences of iron masters who have tried the system is that there is no appreciable difference in the burning or heating powers of the gases; the main heating elements being carbonic oxide, hydrogen and marsh gas which are entirely unaffected by the manner of treatment. 2nd, as to the ammonia output—will it continue to be of value—here again I feel that the question is settled—aside from its value in the various manufactures, its great agricultural market will always be open. The soil is always hungry for this most valuable plant food. The great stores of coal represent more than stored power—these stand for stored vitality and the exponent of that is the ammonia they can yield—it is a wonderful proof of the inter-woven interests of our modern civilization that at last the furnaces and coke ovens are learning to hand over to the farm its portion of the valuable minerals with which they deal. As the basis steel processes are now turning back to the soil the phosphate they take out of the iron, truly it is a great proof of the mighty power of science, showing how she gradually mends and shapes our crude and wasteful industries into a great network of arts which save and utilize more and more carefully the stored treasures of ancient geological life and history making the world more and more able to keep, nourish and handle its growing population,

THE CHAIR. Is there any discussion of this paper?

SECRETARY HASELTINE. Mr. President, I would like to ask Prof. Lord if it would be possible to receive any economic returns from a blast furnace that uses largely Connellsville coke in manufacturing, from the modern furnace that is built now, being 75 to 80 feet in height with a bell top and using a very small percentage of block coal or raw coal to the coke used or if it is only a furnace, as in the illustration used, of about 40 or 50 feet in height and I presume with an open top.

PROF. LORD. I know it was a bell topped furnace. I simply say in regard to that, Mr. Haseltine, that coke furnaces yield too little tar to be of any value and the ammonia they yield is also quite small in amount ; so that thus far, no one has attempted to apply these condensing plants to coke furnaces. They are eminently adapted to raw coal furnaces, of which we have a number in use in the State, as you know. My principle object in presenting the paper, was to call attention to the fact that here in Ohio, we had conditions that should lead to the adoption of the Scotch condensing plants by our furnaces.

SECRETARY HASELTINE. You described the process of extracting the tar and also the ammonia, but did not tell us how they are separated after they have been extracted from the gas.

PROF. LORD. That would extend my paper a great deal. The product of these condensing plants is a mixture of tar, ammonia and water. That mixture passes then to the ammonia works, or it can be sold just as it is to chemical manufacturers.

SECRETARY HASELTINE. The tar is included with it?

PROF. LORD. The tar, ammonia and water, all come out together as mixed material. They separate out by mere gravity. The tar separates underneath and the water on top and they are then treated in the ammonia works. Usually gas works simply sell their tar and ammonia in this crude state to chemical manufacturers who pay for the tar and ammonia and extract and purify these themselves.

SECRETARY HASELTINE. I did not know but they did that at the blast furnace.

PROF. LORD. They do it at some of the blast furnaces, but they have the ammonia works separate.

MR. EDE. Did you arrive at any definite conclusion as to what quantity, say a 120 ton or ordinary furnace such as we have here, what would be the output of these things.

PROF. LORD. I think I gave that, in my paper.

MR. PRICE. I would like to ask one question. You spoke of the gas passing through iron tanks. You also said it went into another tank, and in each tank it went through, there was a spray of water dropping down at the bottom and of course that cooled or condensed the gas and saved the coal tar and ammonia. Now, if this spray of water continues going down there and no water going out, the tank will be filled. How do you save the tar and ammonia and let the water out, as you said a moment ago that the ammonia was mixed with the water and tar.

PROF. LORD. The tar and ammonia are gotten out of the tank by a very simple process. The tank at the bottom has a pipe that discharges this mixture into an outside cylinder and in there the tar sinks to the bottom, the water floats on top and is pumped back all the time on top of the tank and run through again.

MR. PRICE. Then the water you get from the tar has the ammonia mixed with it, is that it?

PROF. LORD. It depends on the plant. Of course the liquid obtained from the works is simply a crude form of ammonia which the chemical manufacturer will convert into a pure merchantable product.

SECRETARY HASELTINE. Mr. President, I move that we extend a vote of thanks to Prof. Lord for his very able paper. The motion being seconded, was unanimously adopted.

THE CHAIR. We are in the habit of doing that for all papers, but I think we can all do that in this case with very heartfelt thanks, because it is a very able paper and something that interests many people in the State of Ohio, and it is a pity

there are not more here. I observe my venerable friend, the President, in the house, and I wish he would come forward and assume the dignity and duties of his office.

At this point President Howells, on resuming the chair, said :

Gentlemen, we propose to vary a little from the program. Mr. Roy has a paper here to be read to-morrow, but as he cannot be here, we would like to have it read the next thing. I do not suppose there will be any opposition to that, so that I shall call on Mr. Roy to read his paper.

