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MODERN COKING AND BY-PRODUCT RECOVERY.

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This subject is one that deserves very thorough consideration in the Engineering fields of Australia. Perusal of Government statistics go to prove our decided backwardness in this industry, and, upon investigation into the underlying causes, the chief feature that strikes one almost invariably is the distinct prejudice that the Australian foundrymen and blast furnacemen hold for Beehive coke. This trouble existed in England in pre-war days to such an extent that we lost to Germany the domination we held over the Iron, Steel, and Chemical markets of the world.

On the outbreak of war in 1914 the United Kingdom found herself plunged into the throes of a great famine in respect to her drugs, dyes, etc.; this being almost a new enemy to face, and then the young Engineer and Chemist of solid Technical training, shot out and ultimately saved the position. A visit to England now, of the same nature that the Author has just been through, will prove to the most sceptical the thorough awakening that has taken place there. Works and Plants of astounding magnitude and efficiency have shot up in the great Industrial centres, and the traditional methods that we in Australia have always curiously accused the Englishmen of, are non-existent, particularly regarding the handling and treatment of coal for its by-products.

The mines of the United Kingdom are now mostly well installed with modern electric cutting and haulage gear, and her coal washing plants gain greater efficiencies than any plants that Germany ever had on the market; and no longer do they transport coal containing 20 to 25% of waste matter over their already over-burdened railroads as we are doing in this country. Then, again, her methods of transportation and general handling of raw materials have improved considerably, and a glance at the figures of the Coking Industry force upon one the fact that a revolutionary recovery has taken place.

Back in 1914 there existed in the United Kingdom 10,000 non-by-product coke ovens belching away into the atmosphere the highly valuable and essential products of some six million tons of coal, while 7,700 plants of the recovery type coked 17,000,000 tons of coal and recovered the by-products. Here the big slump previously referred to took place, and to-day England boasts of 9,100 non-by-product ovens (a decline of 900 in four years) and 9,020 by-product plants, a gain of 20%; thus showing that necessity has been the cause of a distinct defeat of the unscientific methods caused by unfortunate traditional prejudices.

Figures secured from the Home Office in London show where 75% of coke on the English market comes from the modern oven, Germany, whose scientific efficiencies have been the envy of us all, shows a figure of 90%; while the United States, who claim to do things in "big licks," can only attain 60%, but with the number of new plants under order she will seriously rival our figures in the future. Great credit must be given to her in other directions though, for instance, they coke in each oven per annum nearly 6,000 tons of coal where the best of English practice can only show 2,000 tons. The refractory material used by the Americans cannot possibly be of better quality than the English, although they claim it; but where they might win in that respect is on capital cost efficiency.

At the commencement of 1918 the Committee of Coal Conservation (a sub-committee of the Royal Commission of Reconstruction) delivered their findings to the Imperial Government. On broad lines the scheme involved cutting England and Wales in 16 separate districts, each having its own coal fields, and every ounce of coal product from these areas to be destructively distilled by the coke oven in the manufacturing districts and by gasworks in towns where metallurgical coke was not wanted, the resultant gases from these scientific systems were to be stripped of their most valuable products, but kept at the same time of an efficient calorific value, so that they may be converted into electric power of a low cost; and there now exists in England a great controversy between engineers as to what form these gases may be used for electric power generation. Many maintain great efficiency by the use of large units of 20,000 K.W. sets driven by steam turbines, the steam for same being generated in gaseous fixed boilers; (a practice that English engineers are gaining wonderful results at), the other faction is aiming forcibly at units of smaller types, with the motive force from the gas engine.

For engineers there and all over the world this question will be of intense interest. In Durham the Author saw under construction the first of these huge generating stations, and within four or five years the world should benefit from their experience and know the possibilities of large units, whether of steam or gas as prime movers.

Having endeavoured concisely to prove the great power of modern coking and carbonisation from a view-point of National economy, the Author will now attempt the technical side, touching, as briefly as the subject will allow, the requirements, methods and attainments of English practice.

COKING COALS.

There can be very little doubt that we do not yet thoroughly understand coals from a coking view-point, but from the researches of Professors Bone and Lewes, and Messrs. Burgess and Wheeler, we have been considerably enlightened; but up to the present time we have been shown that no definite generalization has yet been arrived at by the correlation of analysis and practical results. The investigations of Professor Lewes have established the fact that four fundamental bases exist in the coking coals, i.e.:--

(a) Carbon residuum.
(b) Humus bodies.
(c) Resin bodies.
(d) Hydrocarbons.

He sets the gas making coals out as a type when the hydrocarbons and resin bodies are in excess, and goes further in stating that these bodies together must be present in the proportion of 50% to form a coking coal. He also has laid down an important axiom in stating that "The higher the Oxygen the lower the coke yield," or "Oxygen above 10% or below 4% indicates very poor coke or a non-coking coal.

In Table No. 1, as below, will be found some analysis of coals I found in use in the different parts of England in comparison to average analysis of coals taken from our New South Wales fields:—

TABLE. No. 1.

Coals from—	Vol. Matt.	HO_2	Fixed Carbon	Ash.	Sulp.
New South Wales—Nth.	41	1·9	50·5	6·25	1·0
" " " Sth.	24	0·71	63·5	11·6	·47
" " " Wst.	32	2·0	53·8	12·5	·67
South Wales	25	10·0	50·0	15·0	·8
Yorkshire	30	1·5	61·0	7·2	·70
Durham	30	7·5	60 5	20·0	2·5
Cumberland	26	2·2	64·0	7·	7·

All coals as received from the mines contain a proportion of undesirable matter, principally shale, pyrites, siliceous matter; these going to build up the ash content. This is a question that has been thoroughly handled in the Old Country, and some astonishing results gained by both the Coppee and Baum people.

The relative specific gravities of coal = 1.25, Shale = 2.6, Pyrites = 3 to 5, is a fact that most washery makers have made use of, and the two firms mentioned make use of water to cleanse their coals, the water in both machines being mechanically agitated.

It is the Author's intention to attempt at a later date a special paper on the matter of Coal Washing, thereby bringing forward some remarkable comparisons between the practice in the United Kingdom and Australia.

COKE.

Blast furnaces are the greatest consumers of coke, the figures of the foundries following very closely.

Composition of coke for metallurgical purposes is an important factor. English conditions look for a composition containing not more than—

10% Ash.
1% to 1.25% Sulphur.
0.2% Phosphorus.

The Americans look for coke of an analagous mixture, and, outside that, are now attempting the specification of cell structure; these people realising the extent of the range of control in the modern oven with its coal mixtures and variable carbonising temperatures, coking periods, width of oven, etc. All these tend to permit of the alteration of cell structure; following experience, their aim is to obtain a coke with 50% cell space, in which the cell walls themselves are strong enough to withstand the large burdens thrown upon them, and at the same time permit of easy access of the oxygen from the blast to the carbon; these walls to be hard, strong and definite, and well coated with graphite film.

MODERN OVEN CONSTRUCTION.

As far as practice in the United Kingdom and Europe carries, the best types of ovens are few, and the author might safely name the types of Koppers, Coppee, Simon-Carves and Semet-Solvay as the leading forms of the modern design. In the United States the leading and most successful ovens are "The American Kopper," the "Wilbutte," and it must be mentioned that all the European types are also in use; but apparently not so popular for some reason.

Later the Author shall describe in detail the above Continental forms; but contends that the two American types mentioned, i.e., "The American Kopper" and "Wilbutte," are worthy of note, their chief feature being their extraordinary dimensions. One case recently before notice showed an oven 40 feet long, 11 feet in height and 20 inches wide; whereas in England the largest oven seen could only count for 34 feet 6 inches by 8 feet 6 inches by 21 inches. The results gained have been previously alluded to when making the comparison on capital cost efficiency.

The designer of the efficient oven has for an ideal the following essential points to work to:—

1. A simple and substantial structure capable of quick and easy repair.
2. (a) Coke, coming up to specifications previous set out (under "coke").
   (b) A high yield of by-products, the gases to be of high calorific value and even quality.

And to obtain such results it is obvious that the heating of the oven is the most essential feature; then again the equal distribution of the heating gases is imperative for that result. The Americans have shown that they do not place a limit to length and height, but that the most perfect results are gained by an oven of a cleverly designed width, and such width must necessarily be governed by the factor of the available or possible working temperature against the nature of the coal being carbonized.

In the description of ovens will be noticed the inclusion of a type with horizontal heating flues, the balance all have the vertical type; the former is now seldom used in England or America.

TABLE No. 2.

OVEN TYPES IN GREAT BRITAIN.

Type.	Reg'n.	W-H.	Total.	Type.	Reg'n.	W-H.	Total
Otto	550	1835	2385	Collin	210	Nil.	910
Semet-Solday	600	830	1430	B.C.O.	25	40	65
Koppers ...	1350	60	1410	Carl Still ..	70	...	70
Simon-Carves	962	738	1700	Mackay-Seymour	30	...	30
Coppee ...	719	108	827				
Simplex ...	194	379	573	Totals... ...	4410	4610	9020
Huessner ...	Nil.	420	420				

Table No. 2 will give some idea of the present distribution of the various forms in use, but the figures are not indicative of the relative merits of each oven, as some totals shown are the result of a much longer business standing of the constructors' firms.

An all-important factor in the design of all ovens is the question of foundations. This is a case that has already been thrust forcibly before us in our own State, where a coal seam of low depth caught fire through its proximity to the sole level, causing a subsidence, and resulting in great damage.

It is only within comparatively recent years that specialised attention has been paid by the coking engineer to the thorough researches of others, and to-day we find the modern oven lined in its courses of intense heat with refractory material of the highest quality. Briefly, it may be of interest to now introduce four clauses from a recent specification for oven linings seen in England:—

(1) Material able to stand 1580 deg. to 1650 deg. cent.

(2) Of a known and well-defined expansion and without contraction at the above temperatures.

(3) Dead true to shape, so that jointing of 3 to 4 mm. may be obtained.

(4) Made of regular consistency, and not likely to warp or become distorted.

In the following pages all regenerative ovens are spoken of as being suppplied with their heating gases from the products of carbonization. This is a practice that most English engineers detest making, and in every case where a good sale can be obtained for these rich gases, they are sent to the market, and a lower grade, typical of "Mond," is used for the oven heating.

Duration of the carbonization or coking periods is a matter that is causing much controversy. A glance at the Table No. 3 will depict how they vary, 25½ hours being the minimum. The Americans are doing 20 and 18 hours over larger charges; but here again we are making comparisons of an unfair nature by comparing "the run of English plants" against the American oven of modern erection and design. The high temperature carbonization naturally means reduced by-product yields, a big consideration.

Table 3 (see attached slip).

Selection as to type has to be first governed by what use on market can be obtained for the resultant gases.

TABLE No. 3.

SOME ENGLISH COKING PLANT RESULTS. (Actual Working).

Nos.	PLANT.	Unwashed Coal. Ash	Unwashed Coal. H_2O	Unwashed Coal. Vol. Matter	Unwashed Coal. Sulph.	Washed Coal. Ash	Washed Coal. H_2O	Washed Coal. Vol. Matter	Washed Coal. Sulph.	Coal Washer Type	Coal Crusher Type	Charging Method
1	Whitwell's, Ltd., Thoraby-on-Tees	7·3	2	25	1·2	7·3	No washing		—	—	Carr	Electric Lorry
2	Skinningrove Steelworks, Saltburn	7	2·5	26	·9	7·0	No washing		—	—	Carr	Electric Lorry
3	Samuelson's, Ltd., Iron-works, Newport	9·2	Dry Test	28	·9	9·2	No washing		—	—	Carr	Electric Lorry
4	Samuelson's, Ltd., Iron-works, Newport	9·2	Dry Test	28	·9	9·2	No washing		—	—	Carr	Electric Lorry
5	Samuelson's, Ltd., Iron-works, Newport	9·2	Dry Test	28	·9	9·2	No washing		—	—	Carr	Hand Lorry
6	Samuel Fox, Ltd., Steel-works, Stocksbridge	7·4	1·5	30	—	7·4	No washing		—	—	Carr	Electric Lorry
7	Wombwell Colliery Barnsby	18	—	—	—	7·3	13	32	—	Baum.	Carr	Hand Lorry
8	Tinsley Park Colliery Sheffield	12	—	—	—	4	—	—	—	Humbolot	Carr	Stamping Machine
9	Horden Colliery, Shotten, Durham	21	—	—	2·5	7·3	8	30	1·7	Meguin	Carr	Electric Lorry
10	Coedelly Colliery, South Wales	15	—	31	—	5·5	11	33	·8	Coppèe	Carr	Hand Lorry
11	Cwmtillery Colliery, South Wales	21	—	24	—	7	10	24	—	Lubric	Carr	Hand Lorry or Compressors
12	Risca Colliery, South Wales	27	—	24	—	7·5	11	—	—	Coppèe	Carr	Electric Lorry

Nos.	PLANT.	Coke Ovens. Type.	Coke Ovens. Nos.	Coke Ovens. Class	Coke Ovens. Dimensions ft. in.	Coking Period hours	By-Products per ton Coal. Sulphate lbs.	By-Products per ton Coal. Tar galls.	By-Products per ton Coal. Benzol galls.	Use of Waste Gases.	Coke Analysis. Ash	Coke Analysis. H_2O	Coke Analysis. Vol. Matter	Coke Analysis. Sulph.	Coke Analysis. Fixed Carbon	Coke Analysis. Phos.	General Remarks.
1	Whitwell's, Ltd., Thoraby-on-Tees	Otto	60	Reg'n.	—	30	25	7·0	2¼	Boilers and Brick Kilns	10	2·5	—	1·2	—	—	Direct Recovering Plant, good amount effluent liquor, scraper plate conveyor for coke.
2	Skinningrove Steelworks, Saltburn	Otto	120	Reg'n.	—	30	25	7·0	2½	Re-heating Furnaces, Stoves and Kilns.	10	6	—	·9	—	—	Fine Recovery Plant producing T.N.T.
3	Samuelson's, Ltd., Iron-works, Newport	Otto	130	W-H.	34 6¼ 8 3 1 9	30	21	8·0	2¼	Boilers, Ovens and Town Lighting	11·7	Dry Test	·85	1·2	—	—	Very Old Plant.
4	Samuelson's, Ltd., Iron-works, Newport	Otto	46	Reg'h.	32 7 6 7 1 9	30	21	8·0	2¼	Boilers, Ovens and Town Lighting	11·7	Dry Test	·85	1·2	—	—	Plant doing good, producing a splendid coke and gas for lighting.
5	Samuelson's, Ltd., Iron-works, Newport	Simon-Carves	35	W-H.	—	40	21	8·0	2¼	Boilers, Ovens and Town Lighting	11·7	Dry Test	·85	1·2	—	—	Plant still working, but about to be replaced by Otto type.
6	Samuel Fox, Ltd., Steel-works, Stocksbridge	Simon-Carves	60	Reg'n.	—	25½	31	7·5	3·1	Boilers and Stills	12·2	5	1·5	·66	85	·06	New Plant. Results shewn on 30 ovens only. Coke screened and breeze is bunkered.
7	Wombwell Colliery Barnsby	Simon-Carves	50	W-H.	32 8 8 2 1 9½	33	31	8·5	3·5	Boilers	10	3·5	1	1·7	—	—	Splendid coke produced Additions made for stamping if necessary.
8	Tinsley Park Colliery Sheffield	Koppers	55	Reg'n.	32 8 8 3 1 7	35	29	9·5	3·0	Town Lighting and Boilers.	11	3	1·5	1·6	—	—	Giving an excellent coke. Only 40 ovens under fire.
9	Horden Colliery, Shotten, Durham	Koppers	60	Reg'n.	32 5 8 6 1 9	26	29·3	9·5	2·7	Boilers	10	1·6	1·4	1·6	87	·02	Excellent Layout and Plant. Electric haulage coke-car, and pressure quenching
10	Coedelly Colliery, South Wales	Coppèe	60	Reg'n.	33 0 8 4 1 8	30	22·5	6·2	2·4	Boilers	8	2	—	·8	—	·03	Dempster Tar Stills in use.
11	Cwmtillery Colliery, South Wales	Coppèe	50	W-H.	33 0 8 2 1 5	25½	22·5	4·2	2·2	Boilers	10	4	—	·9	—	·06	Boiler firing here gives 1 lb. of steam to 1 lb. of coal carbonized in ovens.
12	Risca Colliery, South Wales	Coppèe	45	W-H.	33 0 8. 2 2 0	35	24·6	8·9	2·1	Boilers	10	3	—	·7	—	·06	Splendid Layout and most efficient Recovery Plant

COKE OVEN GAS ANALYSIS

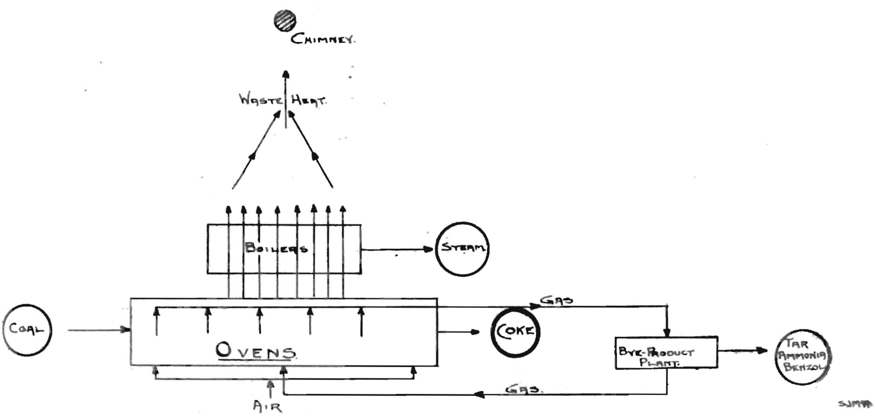
MIDDLESBROUGH.	SHEFFIELD.
$CO = 8{\cdot}1$ %	$CO = 3{\cdot}45$ %
$H = 49{\cdot}1$,,	$H = 47{\cdot}60$,,
$CH_4 = 32{\cdot}6$,,	$CH_4 = 35{\cdot}13$,,
$N = 6{\cdot}6$,,	$N = 7{\cdot}45$,,
$O = 0{\cdot}5$,,	$O = 0{\cdot}21$,,
$C_2H_4 = 3{\cdot}1$,,	$C_2H_4 = 3{\cdot}67$,,
Calorific Value 520-60 B.T.U.	—— 580-5 B.T.U.

COKING LABOUR.

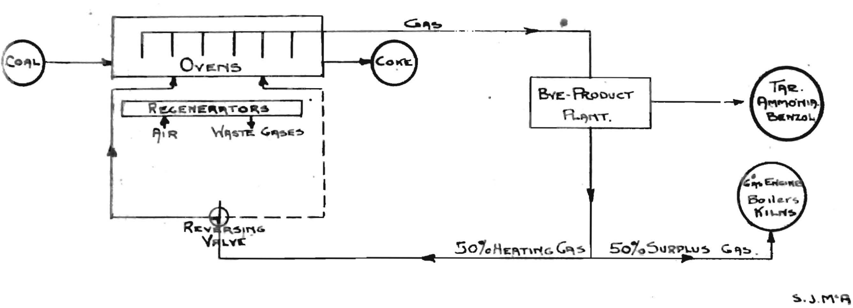
Under Average English Conditions a Battery of 50 Ovens and Recovery Plant requires a staff of 1 Foreman and about 17 men per shift.

In the waste heat oven the hot gases produced by the combustion in the oven flues pass direct to the boilers generating steam. (See Fig. No. 1.) In the regenerative oven (see Fig. No. 2) waste gases pass through the regenerators and heat up the incoming air for combustion: thus reducing the fuel account enormously. In general practice it is found that most ovens require 50% of the evolved gases for their heating purposes, leaving 50% for town lighting, gaseous boiler firing, etc.

No 1 Waste-Heat Oven Diagram.



No 2.- Regenerator Ovens Diagram



Production of Power from Coke Oven Gas.

The Regenerative Oven.

Take 50 medium ovens, reg'n. type, coking 360 tons of coal per day. Available gas = 50% of 10,000 cub. ft. per ton = 5000 × 360 = 1,800,000 cub. ft. Gas Engines at 21 cub. ft. per B.H.P. hour.

This should develop:—

$$\frac{1,800,000}{21 \times 24} = \text{about } 3,500 \text{ H.P.}$$

or about 2,500 KW.

The Waste-Heat Oven.

Take 50 medium waste-heat ovens, coking 350 tons of coal per day with the W.H. oven, English practice shows that one ton of steam can be produced from one ton of coal, and with superheated steam used in turbines the consumption is about 11lbs. per H.P. hour.

The power thus produced:—

$$\frac{350 \times 2,240}{11 \times 24} = \text{approx. } 3,000 \text{ H.P.}$$

or about 2,000 KW.

The Semet-Solvay Waste-Heat Oven.

This type, as shown by Fig. No. 3, is the one previously referred to as the horizontal heating flue form, and quite probably the best known of that class.

In the longitudinal section a, a, are the coal-filling holes, "b" being the gas off-take, and leading to foul main.

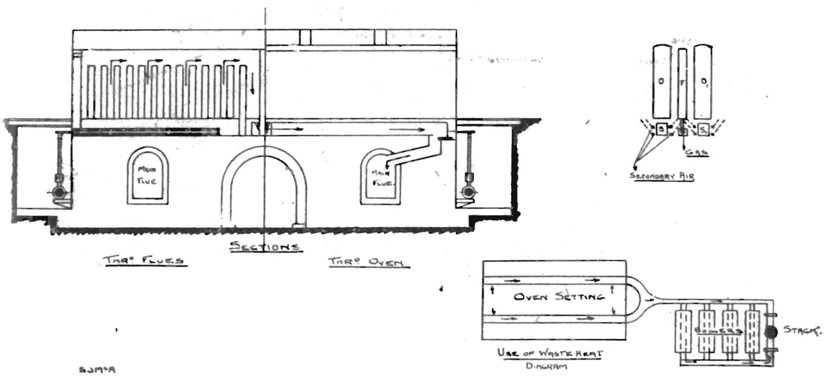
"C1, C2, C3, C4," are the four horizontal heating flues, the products of combustion from the gas and air admitted respectively through the gas mains "M and M," and through flue "E," are carried over the course of these flues as shown by arrows, then passing along sole flue "D," and out into main flue "F."

Fig. 4 illustrates the addition of a regenerator to the Semet-Solvay oven, the main feature being that each coking chamber has its independent recuperator, and the waste gases in coming away are drawn by the stack draught through this recuperator into the flue "F," while the cold air from "E" passes over the fire clay tubes carrying the waste products up for combustion with the gas, as in the waste-heat type.

Coppee Waste-Heat Oven.

As shown in Fig. 5, the Coppee waste-heat oven has the usual oven side walls containing the vertical flues, comprising 24 uptakes and 2 large downcast, which are divided by a partition wall in the centre.

No. 5 Coppée Waste Heat Oven.



The gases for heating the oven walls are brought back from the by-product plant in the two gas mains, shown either end of the oven, led through a mixing chamber fixed on smaller tube, similar to the Bunsen burner, then into the fireclay tubes running under the uptakes, corresponding to each flue an aperture is drilled, naturally of varying diameters. Running parallel with the sole flues "S and S," will be noticed secondary air openings; combustion taking place at the base of each uptake, the