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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 40 OF 1963.

RESEARCH ON THE PRODUCTION OF METALLURGICAL COKE.

BY:

DR. A. J. PETRICK.

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RESEARCH ON THE PRODUCTION OF METALLURGICAL COKE.

INTRODUCTION:

During 1958 Iscor and the Institute agreed to undertake a joint research programme to evaluate certain potential reserves of coking or blend coking coal (e.g. Waterberg and Soutpansberg) and to study problems associated with the production of metallurgical coke. (Sasol participated to some extent in the early stages of the investigation.)

The original laboratory and pilot plant programme was largely based on suggestions submitted in a memorandum (F.R.I.Technical Memo. No. 4 of 1958) prepared by the Institute.

These suggestions comprised matters such as the study of methods for evaluation of coals (chemical, physical and microscopic techniques), pilot plant work in coal preparation and carbonisation, and studies in briquetting and metallurgical matters such as the reduction of ores. Large scale oven tests were envisaged.

At the time it was resolved to continue with practically all the suggested studies. Iscor would, however, hold itself responsible for exploratory work on briquetting and metallurgical matters.

The ..../

The original work was largely centered around the study of Waterberg and Soutpansberg coal, and some coals from the Witbank coalfield. Comparatively small quantities of coal were dealt with and carbonisation experiments were done mainly in the pilot plant ovens.

Through its survey activities the Institute became aware of certain other reserves of coking coal, and although some were not large, coal from these areas were included.

Since about 1961, Iscor's general expansion plans necessitated a more rapid assessment of all reasonably promising occurrences of coking or blend coking coal from Natal and the Transvaal, and the earlier laboratory and pilot plant work was increasingly amplified by large scale oven carbonisation experiments. During 1962 and 1963, such large scale work was almost continuous and in this connection about 4,000 tons of coal was washed annually at the Institute's pilot plant, apart from coal used and washed elsewhere. Over 200 full scale oven experiments had been done when the work was discontinued in August 1963.

This combination of laboratory research, pilot plant and large scale carbonisation is probably unique in carbonisation research history.

During 1962/63, Iscor has shown increasing interest in the production of a harder - less abradable - coke of lower ash content and much of the more recent experimental work was done to determine what could be achieved in this respect.

When .../

When it was decided to discontinue the large scale carbonisation experiments towards August 1963, virtually all the presently known sources of coking and blend coking coals of any promise had received at least some attention.

SOME CONCLUSIONS:

A full assessment of the results of the investigation will not be available for some time but one is justified to draw some conclusions, e.g.,

1. The value of a number of laboratory methods for assessing the coking propensities of coals could be proved. The B.S. swelling index was found not to provide a reliable guide.

2. The petrographic analysis of coals and the microscopic examination of cokes provide valuable information on the suitability of coals and blends for coke manufacture. The results should be considered in conjunction with laboratory tests such as the dilatometer, the Roga and the Brabender plastograph tests.

3. The Waterberg bright coal, formerly classed as coking coal, should rather be classed as blend coking coal. As such it may be useful in various respects.

4. The coal from some of the lower seams in the Waterberg coalfield and from the No. 2 Seam Witbank, could provide blend coking coal of lower ash content than the prepared blend coking coal presently supplied from the Witbank No. 5 Seam, but the coking properties are not as good as those of the prepared No. 5 Seam coal (Springbok).

Nevertheless, .../

Novertheless, these coals could be used as blend coking coals provided enough (about 30%) of good coking coal is used in the blend.

5. Only one area (Greenside holding) of the No. 5 Seam coal was found that could yield blend coking coal as good as, or better than, that obtainable from the Springbok No. 5 Seam.

6. D.N.C., Northfield and Hlobane Collieries are the best sources of coking coal. A valuable - even if not large - reserve was located at Indumeni while the coking seam at Tshoba yielded excellent coking coal, but the seam is thin and the reserves are, therefore, probably small. A limited amount of coking coal is also produced from the Dundas and Coking Seams at Enyati Colliery.

7. The Soutpansberg coal can be classed as a coking coal with high volatile matter content, at least, in the area on which Iscor concentrated its prospecting activities. (Unfortunately this coal is intergrown with shale to such an extent that one has to speak of coal zones (composed of a preponderance of coal) rather than of coal seams. No opinion can be expressed on the mining problems involved, but the preparation of the coal presents quite a formidable problem.

It may be noted that in this case it was generally found that froth flotation products (treating $-\frac{1}{2}$ mm fines), at a reasonable yield, had lower ash contents than the cyclone products (treating $-\frac{1}{2}$" $+\frac{1}{2}$mm coal) - while with most of the other coals studied the froth flotation product had the higher ash content.)

8. Charging .../

8. Charging of virtually air-dried coal to ovens instead of coal having a moisture content of about 8%, improved the quality of the coke. (The average size of the coke and the shatter index ($1\frac{1}{2}$") were hardly affected but the abrasion index was greatly improved.)

SUMMARISING, it would appear that the coking coal demands of Iscor, Amcor and colliery producers of coke for the general market, can possibly be met for the next 15-20 years by exploiting sources in the accessible or developed coal-fields of Natal and Witbank-Middelburg.

The large Waterberg reserves will probably not yield an acceptable metallurgical coke (on the basis of conventional coke oven practice) unless the prepared coal from that area can be blended with an adequate proportion (25-30%) of good coking coal.

If the steel industry should maintain its present rate of growth in the future, and should concentrate on larger blast furnaces, serious attention will very soon have to be given to finding other acceptable reserves of coking coal or other means of obtaining an acceptable carbon reductant or "conventional coke substitute" from other sources.

Presently known reserves of low ash blend coking coal may have to be used with circumspection so as to ensure that such coal will be available for blending with relatively high ash coking coal e.g., that from Soutpansberg.

FUTURE .../

FUTURE RESEARCH:

A. Immediate Future.

As regards the immediate future, one relevant problem appears to be to obtain coke of sufficient strength to ensure good operating conditions in the large diameter blast furnaces now being built. At the same time Iscor would probably desire, if possible, a reduction of the ash content of the coke.

If sufficiently strong coke can be made, attention will probably also be given to the injection of gas, oil or pulverised coal through the tuyeres of the blast furnaces. In the latter case it would be desirable to have available a coal of low ash content.

The following research programme is therefore visualised.

(1) The strength of the coke that can be produced from the type of blends presently used by Iscor can probably only be improved by increasing the bulk or charge density of the coal in the ovens.

It has already been mentioned that favourable results have been obtained by "air-dry" charging.

In pilot plant experiments, such air-dry charging had about the same beneficial effect as stamp-charging. It can probably be accepted that Iscor would give preference to "air-dry" or even "dry" charging. This avenue should, therefore, be explored further.

Other possibilities for raising the charge density, that have been studied elsewhere are:
(a) oiling the coal (often not very effective),
(b) increasing the height of coke ovens (probably

not .../

not practical at Iscor) and (c) compressing the charge coal into relatively weak (binderless) briquettes and charging these in the normal way - although a fairly high degree of breakage occurs, increased charge densities are apparently obtainable.

This last named alternative may be studied at the Institute as soon as a suitable press is available.

(2) Fundamental work should continue so that information about the process of coke formation and bonding may be obtained.

(3) Attention will be given to other possibilities of improving the coke strength by, for example, more judicious blending, introducing other blend constituents, varying the sizing of components.

(4) Continued attention will have to be given to the preparation of coal, either for using in coking blends or for possible injection through tuyeres.

B. Longer Range Research.

Various items are mentioned under this heading merely because present policies or economies probably preclude their early application.—

As regards blend coking coals, the only "untapped" reserve in the more developed coalfields is the fines arising during the mining of the No. 2 Seam at a number of Witbank collieries and fines produced at some collieries in Natal. Excluding Kudu Colliery and Greenside properties already earmarked for mining, no untapped reserve of Witbank No. 5 Seam coal of reasonable magnitude and yielding a prepared coal with a swelling number appreciably

above .../

2 is known.

The No. 2 Seam duff and pea-duff have been studied on various occasions at the Institute and present activities are confined to periodic checks of the washability characteristics and the coking properties of the lighter specific gravity fractions of samples from selected collieries.

Patches of coking coal are known to exist in Natal, but most of them are probably so small individually (in terms of reserves) that the opening up of a separate colliery with preparation plant may not be justified. Some might be exploited in conjunction with other mining operations. The only known sizeable virgin reserve is probably that at Milnedale. Mining possibilities and economic considerations determine whether exploitation will take place. In some of the cases investigated by the Institute no serious coal preparation problems arise.

The Institute could only make a contribution to any investigation after mining and economic questions have been settled.

On the other hand, the potential value of the reserves in the Waterberg and Soutpansberg coalfields is so great that continued attention should be given to the problems associated with the utilisation of this coal.

Mining aspects are obviously outside the scope of the Institute's activities and it will confine its attention to preparation and carbonisation problems.

A reasonable reserve of Soutpansberg coal has been secured by the Institute, but very little Waterberg coal is available. —

The ..../

The object of research on such swelling coals would be to find, if possible, more satisfactory preparation techniques (better separation of coal and mineral constituents at lower cost) on the one hand and, on the other hand to determine how these coals may be used to best advantage in the production of hard metallurgical coke of acceptable ash content.

The present indications are that prepared swelling coal from sources such as Waterberg and Soutpansberg would cost more at the coke ovens than coal presently supplied.

Therefore, alternative methods of producing hard coke may come within the realm of economic interest in a few years.

It appears to be fairly obvious that in South Africa such a "conventional coke substitute" may have to be made wholly or mainly from weakly or entirely non-coking coal. This raw material would, therefore, have to be formed or briquetted prior to hardening or carbonization.

C. Production of "Form-Coke".

The idea of making a hard coke by briquetting fine coal and heat treating the briquettes is, of course, not new.

The possibilities have been studied in various countries, e.g., Great Britain, Germany and United States of America. As far as the writer hereof is aware only Didier - Kogag-Hinselmann of Germany, actually erected a plant (in South America). American interests have recently given considerable publicity to the idea, but apparently

they ..../

they have only operated a pilot plant(F.M.Coke).

In most of the industrial or developed countries possessing coking coal reserves such products have not been able to compete with conventional coke in blast furnace operation.

Current suggestions for making form coke include:

1. Conventional briquetting in double roll presses of mixtures of coal and binder and subsequent treatment which varies from mild heat treatment in an oxidising atmosphere to carbonisation at high temperature.

2. Briquetting of coal with or without a special binder in some form of extrusion press. If no binder is used the operation has to be done at a temperature high enough to obtain bonding by the "plastic constituents" of the coal.

3. Briquetting in Ring-Roll-presses (exerting higher pressure than double roll presses) at normal or high temperature (depending on whether binder is added or not).

4. The strength of briquettes is reported to be increased by giving the raw, hot briquette a "twist" in a press of special construction.

Briquettes made by processes 2, 3 and 4 may still require a hardening treatment.

Various suggestions have been made to reduce the overall production costs. Since the binder constitutes an important cost item, particular attention has been given in some quarters to the binderless briquetting of bituminous coal.

It ..../

It is gathered that this must be done either at reasonably low temperatures but extremely high pressures or at high temperatures (within the softening range of the coal) and relatively lower pressure.

In either case the conditions are severe and the press has to be made from specially resistant alloy.

The impression was gained from recent N.C.B. (of Great Britain) reports on hot briquetting that the press-material-problem has not yet been solved entirely. The briquetting at very high pressure and lower temperature is probably more advanced at this stage. Such presses are, naturally, more expensive than the more conventional double roll presses.

SOUTH AFRICAN RESEARCH:

Notwithstanding the extensive research done in for example, Europe on briquetting and the hardening of briquettes, there is ample justification for South African research.

One very pertinent reason is that the research done in most European countries was essentially based on swelling coals. In fact the coal is frequently oxidised before briquetting to reduce its swelling properties.— To the best of the writers knowledge, anthracite briquettes are only made to satisfy the domestic (household) market. — The South African problem is to make hard briquettes from non-coking coal.

Secondly, it is very desirable that South African scientists and technicians obtain practical knowledge of the processes involved if they are going to find application in this country.

Furthermore, .../

Furthermore, it would be desirable to approach the problem with full cognisance of the South African fuel position. The process cost factor is more important here than, e.g., in Europe, because any processing cost affects the final price of the fuel or coke (percentage-wise) more in South Africa with its relatively low priced fuel than in Europe where the fuel price level is so much higher.

WORK ALREADY DONE:

It is understood that Iscor's research on briquetting has, so far, largely been concentrated on the briquetting of coke breeze, although attention has also recently been given to the hot briquetting of weakly coking coal. An hydraulic press making single, cylindrical briquettes was used. The binderless briquettes made from weakly coking coals were apparently not very hard.

Some years ago, the Institute did some experiments in a makeshift apparatus on the hot briquetting of coal having a fair swelling number. In this case it was found that the briquettes were inclined to swell appreciably when the pressure was relieved while the briquette was still fairly hot.

FUTURE RESEARCH:

Since the South African raw material will be essentially non-coking coal, it appears that completely binderless briquetting will not be feasible. Some binder, be it coking coal, pitch, starch or sulphite liquor will have to be added to obtain briquettes of sufficient strength to withstand handling etc. until the hardening treatment is completed.

If ..../

temperature only.

SCOPE OF RESEARCH PROGRAMME.

It must be stated that the briquetting project is not planned with the sole object of making metallurgical briquettes.

The facilities will also be used to study the production of reductant for electro-metallurgical processes and the production of domestic fuel.

CAPITAL REQUIREMENTS:

Although enquiries were made in August, no comprehensive figures can be given in this memorandum. Estimates may be available early in December.

It can only be stated that pilot plant briquette presses of conventional design (double-roll) and a capacity of about 5 tons/hr. are quoted at about R10,000.

Provisionally a briquetting plant is visualised having storage capacity for raw materials, dryers, crushers for coal and binder (pitch), mixers, pre-heaters, two or more presses, coolers and storage for finished briquettes, with of course, the necessary handling equipment. Steam could be supplied by the existing experimental boiler, but it is obvious that the total cost of the plant could be of the order of R100,000.

(SIGNED) A. J. PETRICK
DIRECTOR.

PRETORIA.
13/11/1963.