F.R.I. 47

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VAN _____

REPORT NO. 2

OF 1971

FRI 2/1971

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BRANDSTOFNAVORSINGSINSTITUUT
VAN SUID-AFRIKA

FUEL RESEARCH INSTITUTE
OF SOUTH AFRICA

ONDERWERP:
SUBJECT: THE NEED FOR RESEARCH ON PILOT PLANT SCALE AT THE FUEL RESEARCH INSTITUTE.

AFDELING:
DIVISION:

NAAM VAN AMPTENAAR:
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I N D E X

FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

REPORT NO.2 OF 1971

THE NEED FOR RESEARCH ON PILOT PLANT SCALE AT THE FUEL RESEARCH INSTITUTE

(With special reference to the planned plant for formcoke and allied studies.)

INTRODUCTION:

In the parlance presently in vogue in South Africa, the Fuel Research Institute would be classed as an Industrial Research Institution.

This signifies that the emphasis in research falls on problems of direct interest to the industries served by the Institute. This does not imply, however, that such an institution is simply a "trouble shooting" organisation or even a centre confining the attention to problems of immediate and, frequently, transient concern.

The Institute must certainly be prepared to undertake such studies. It can only do so efficiently, however, if adequate facilities are available and if its staff possesses sufficient expertise to bring such studies, at least, to a reasonably successful conclusion while the problem posed is still of real interest to the industry concerned.

All this really implies that for efficient operation such an institution should ideally have done so much spade work (including training of staff), forestalling the problems that may be posed, that it either already has the answers ready when it is approached or is so well organised in terms of facilities, expertise or know-how that immediate action

can .../

can be taken to provide an answer in a minimum of time.

Such preparedness is desirable, not only concerning problems in the context of present technology and economic conditions (e.g. market demands and quality criteria) but also in respect of those arising from changing situations of supply and demand including the industry's desire to extend the basis of its market activities.

In fact, the staff should be virtually clairvoyant to determine well in advance how the situation is likely to develop. In the long run the value of an institute to the industry will largely depend on the degree of success in such clairvoyance or forward planning.

This is in no small measure particularly apposite to the dynamic energy-supply-industries. —

Even if the emphasis in an institution falls on applied science or technology, it cannot divorce itself from fundamental research. It will certainly make use of as much fundamental knowledge about a subject as it can possibly glean from standard reference works or current scientific journals. Experience has shown, however, that in very many instances the specific information sought is not entirely to be obtained in this way. Therefore, fundamental studies must be undertaken. Generally, however, the work is undertaken to obtain the desired answers and will not continue indefinitely, however interesting the study may be.

More often than not, applied research is initially done on a laboratory scale. This may be followed by more or less modest bench scale studies.

Pilot plant scale work is inevitable for any industrial process. One reason is that, not only, the technical feasibility but also the commercial-economic possibilities of the process have to be established. This can usually not be done adequately from the results of a laboratory "set up". The

size .../

The size of pilot plant required at the research institution itself depends on the particular process and is best determined jointly by the institute and the industry(ies) served. (Compare, for example, the South African Leather Research Institute, Textiles Research Institute, Sugar and Fisheries Research Institutions.)

These statements can best be evinced by a review of developments at the Fuel Research Institute.

EARLY WORK AT THE FUEL RESEARCH INSTITUTE.

For a number of years after the Institute had been established in 1931, its studies were centered around the characterisation of the coal types available in the country (the physical and chemical survey of coal resources).

A conclusion drawn from these studies was that more detailed research on coal preparation and the production of coke from South African coal was desirable.

While survey work continued and attention was given to these matters in the course of that work, efforts were also made to initiate special studies on these subjects.

In the survey work, largely based on the analyses of borehole cores, float and sink separations were done on coal crushed to about minus 20 mesh.

For more specific washability studies on commercial size grades a "coalometer" was acquired.

Efforts were also made to work at collieries but these studies only gained impetus much later. This was partly due to the fact that in the thirties comparatively few collieries had installed coal washing plants.

The float and sink analyses on minus 20 mesh coal could be done very conveniently in the laboratory. Representatives of industry pointed out, however, that the results had

little .../

little practical meaning. After discussions with such representatives it was finally agreed to do the analysis on borehole core samples after crushing to minus 1 inch. This was considered to constitute the best practical solution, although it has disadvantages. For other studies the analyses should be done on representative samples of commercial size grades. For the time being such work had to be done using the coalometer — a somewhat tedious operation especially when dealing with the relatively bulky samples of the larger coal sizes.—

Until the late thirties carbonisation research remained limited to laboratory experiments amplified by socalled "box tests" conducted with the cooperation of Iscor. Some large scale tests were done with the cooperation of Iscor and other coke manufacturers (largely confined, as far as the Institute was concerned to the sampling and analysis of the coal charged and the coke produced).

THE PERIOD 1940 - 1958.

While work of the nature described continued, special attention was given to the smaller coal size gradings (peas and duff).

In the early days of coal mining in South Africa, virtually all coal smaller than one inch was dumped as unsaleable. By 1940 the position had improved in that peas were in demand and even duff (often in conjunction with peas) could be sold. Nevertheless, large quantities of duff were still being dumped. At the time it appeared that the position might be aggravated as the market for lump coal dwindled and collieries would be forced to reduce the top size of coal offered for sale.

The Institute, therefore, decided to study the duff problem more closely. It was found that quite good yields of swelling coal could be recovered from the duff arising

at .../

at many collieries.

Admittedly the study was based on "theoretical" float and sink separations. Nevertheless, the Institute was taken aback somewhat at the completely negative reaction of the coal industry and Iscor to the suggestion of double-washing the duff from selected collieries to produce a swelling "blend coal" fraction and a middlings of very nearly the same quality as the duff normally offered for sale from these collieries. The technical feasibility as well as the economic advantage of such a process were doubted.

In 1947, the first publication on the Dutch State Mines Cyclone Washer appeared. Although the information was scanty, the matter was taken up at the Institute. Dr.P.J. van der Walt conducted exhaustive studies on a number of cyclone types in a small unit built at the Institute, which nevertheless had a throughput of the order of 1 ton/hr.

Even this research did not convince the majority of engineers of the coal industry of, at least, the technical feasibility of producing a "blend coking coal" from duff.

The greater interest in coal washing thus created led the Fuel Research Board to agree to send Dr. van der Walt to the United Kingdom for a fairly extensive study of current coal washing practice. After his return much more systematic studies on coal washers at South African collieries were started.

Mine managers were generally very cooperative and allowed the Institute's staff to test washers, set for normal production. This provided a very valuable opportunity for a number of staff members to gain experience.

As experience was gained and mutual confidence was established, officers of the Institute were asked to render assistance in solving washery problems, experienced from time to time. On such occasions limited changes in

settings .../

settings could be applied — with discretion, bearing in mind the economic implications of producing large tonnages of unacceptable coal.

Such studies drew the attention to matters such as dense medium preparation and properties, i.al. contamination by slurries. This led e.g. to fundamental research on magnetite ores used for dense medium preparation (e.g. viscosity of suspensions, settling rates, demagnetisation and generally the magnetic properties of magnetites) and the initiation of froth flotation studies.

As the interest in coal washing increased, requests for information on the characteristics of particular coal types were received from both coal owners and appliance manufacturers. The Institute could only assist by determining washability characteristics in the coalometer. On occasions arrangements were therefore made by coal owners with other collieries to wash consignments of coal in their commercial plant. The Institute was asked to assist.

It was generally found that there was no provision for feeding a "foreign" coal into the washery and also that sampling facilities were inadequate or non-existant. Tests could only be done while the washer was not being used by the colliery itself and make-shift facilities for storing and feeding the foreign coal had to be erected without interfering with normal operations. The result was sometimes "catastrophic" (e.g. collapse of temporary structure).

The amount of "foreign" coal needed, to be able to set the washer and to obtain meaningful results, was generally in the order of a few hundred tons.

The problems experienced were frequently so great that no really useful results were obtained during the "battle" to operate the plant from midday on Saturday through Sunday. —

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During .../

During this period coal owners and contractors began to find it expedient to request the Institute to do acceptance tests on newly installed washers.

It eventuated that the work could be done to the entire satisfaction of coal owners and contractors at a half to a third of the cost that would have been charged by consultants called in from elsewhere. —

Out of all this experience the idea of a coal preparation pilot plant was born.

Initially very few members of the coal industry showed any interest. More encouragement was obtained from appliance manufacturers who saw therein the possibility of obtaining the much sought practical data on coal characteristics required for designing plant and for providing guarantees.

Eventually, however, the coal industry and Iscor agreed to provide capital and with the assistance of appliance manufacturers (donation of plant or provision of plant at greatly reduced prices) detailed planning became possible.

This planning was placed in the hands of a committee established by the Fuel Research Board and composed of representatives of Iscor, the coal industry and the Institute.

In order to create a plant that would provide the interested industries with results of real practical meaning units having capacities in the region of 15 - 20 t.p.h. were chosen. However, by planning for a system of recirculation of coal etc. it has been possible to obtain useful results in some units using only about 5 tons of coal.

The plant is adequately described elsewhere. Suffice it here to say that a highly flexible and versatile plant was provided.

As a necessary adjunct the facilities for sampling and doing detailed washability analyses were considerably expanded. These facilities were needed to study the feed to and products recovered from the plant. These facilities have,

however, .../

however, been in increasing demand by colliery companies requesting the determination of the washability characteristics of coal types. —

While carbonisation studies along the lines described continued, further progress was made by installing an electrically heated pilot plant oven taking a charge of 600 lb. This plant, although useful, was found not to be quite satisfactory.

THE PERIOD SINCE 1958.

The Coal Preparation Pilot Plant was officially opened in 1958. The Fuel Research Board decided to perpetuate the planning committee and to maintain the active interest of the industries that had assisted so materially, by converting the committee into a standing Pilot Plants Advisory Committee having, as terms of reference, to consider and make recommendations on research projects to be done in pilot plants, to advise the Board on modifications and additions to pilot plants and to recommend estimated expenditure at the pilot plant site.

It was decided firstly, to invite the industries to suggest projects for research and secondly, also to advise that work could be done on behalf of individual companies. It was resolved to charge a nominal fee of R2 per ton of feed for washing tests and not to aim at a full recovery of costs. Fees earned would be used to build up a conservation, replacement and development fund.

Practically no reaction was obtained to this invitation. The staff therefore undertook research to obtain more detailed information on plant operating characteristics and the characteristics of various coal types.

The first major programme of a more practical nature was a joint survey undertaken by Iscor and the Institute on the preparation and carbonisation of various swelling coals.

This .../

This embraced the preparation of quite large consignments of coal to various quality standards and subsequent large scale carbonisation tests on these coals blended in various proportions. Detailed work was done on the analysis of the coals, the blends charged and on the coke produced.

Apart from the benefits acruing to Iscor, this study had the effect of increasing the awareness of the coal industry to the fact that a useful facility existed, as it were, on their doorstep.

As the sixties advanced the Institute was consequently approached more frequently with requests to treat consignments of coal, either to establish what type of washer might serve a particular purpose or coal type best, or to prepare coal for subsequent testing in South Africa or elsewhere. Since 1968, the number of requests increased to such an extent that very little operating time remained to conduct any particular research programme.

Lately appliance makers, realising the value of such facilities (as constituting practically a demonstration plant) have offered certain equipment either as a donation or on a permanent loan basis, to be installed in the pilot plant (e.g. froth flotation cells and various coal washing units). Such assistance renders the plant even more versatile.

The value of the pilot plant as a training unit is being more widely recognised.

The trained F.R.I. staff has also been asked to assist with the training of plant operators elsewhere and with conducting the practical examinations of plant operators.

TONNAGE TREATED.

During the sixties, some 21,000 tons of coal composed of consignments ranging from 5 tons to 500 tons have

been .../

been treated in the pilot plant. This comprised -

coal treated on behalf of Iscor alone	8,000
coal treated on behalf of individual colliery owners only	5,000
coal treated in studies of interest to Iscor and colliery owners jointly	8,000

In 1970 alone 4,500 tons of coal were washed at more than one specific gravity.

THE CARBONISATION PILOT PLANT.

The ability to prepare coal to tight specifications in the coal preparation pilot plant greatly stimulated work on the production of metallurgical coke.

As already indicated, extensive carbonisation tests were done in Iscor's coke ovens

This opportunity was taken to do detailed laboratory work on samples of the coal charged (individual components and blends) and of the coke produced, to determine to what extent the results of laboratory analyses (chemical analyses, "coking" tests, petrographic analyses, reflectivity measurements) could be used to forecast the quality of the coke that might be produced.

This was a most informative study. It proved, however, that the large tonnages of coal required, made the investigations expensive and thus tended to limit the number of tests done in any study of the effect of variations in experimental conditions.

The need was felt for a carbonisation facility of intermediate size that might be more flexible and would lend itself to more exhaustive experimentation. The electrically heated oven, mentioned earlier, did not provide an entirely satisfactory answer.

After .../

After investigating other avenues, Messrs. Woodall-Duckham were approached and this company agreed tc donate two gas-heated pilot plant ovens to the Institute. This offer and assistance and a capital grant from Iscor, augmented by Institute funds, enabled the Institute to provide a useful carbonisation facility that has been increasingly in demand by Iscor and colliery owners.

The plant is rather more flexible than the large scale ovens. Experiments have been done under various operating conditions. In the course of these studies, conditions have been established yielding results correlatable, if not entirely identical with those obtained in Iscor's ovens. These conditions are used in comparative tests. Other operating conditions are used if requested.

Much contract work is done in these ovens only.

When large consignments are to be carbonised in Iscor's ovens, enough coal is usually procured to do small scale tests at the same time — thus steadily improving the correlation factors.

During the period 1969/70 both pilot plants were largely occupied with investigations to establish the possibilities of recovering coking or blend coking coal from the smaller size gradings of coal produced at Natal and Transvaal collieries. The results of these experiments are sent to either the N.A.C. or the T.C.O.A., as they become available.

PILOT PLANT FOR THE STUDY OF COMBUSTION PROBLEMS.

After the coal preparation pilot plant had been brought into successful operation, it was deemed to be desirable to have a facility for the study of the combustion characteristics of the various fuels that could be produced in this plant on a technical scale including middlings or discards, produced when washing at low specific gravities, and naturally arising fuels of high ash content. Difficulties

arising .../

arising from clinker formation and the occurrence of fire-side deposits could also be studied.

As the efficiency at which small and medium sized boiler plants were operated in practice was appalling at the time, such a plant could also be used to demonstrate that coal could be burnt efficiently and smokelessly, also on smaller sizes than the customary cobbles, mainly used.

In addition to a small vertical boiler, which could be operated by hand firing or with an underfeed stoker, already in the possession of the Institute, a triple pass (super economic) shell boiler of 5,000 lb per hour steaming capacity, equipped with a chain grate stoker was acquired.

Members of the Institute's staff collected considerable experience in the operation of various types of boilers and fuel and were frequently approached to give advice and instruction to owners of steam raising equipment.

When a few years after the establishment of the boiler pilot plant, the promotion of smokeless combustion in domestic,and similar small appliances became a matter of urgency, a staff well acquainted with combustion matters on a practical scale was available. Due to the shortage of other experienced staff, these had to be used for work in this new field and few systematic investigations on the boiler plant were performed for some years.

Lately, the staff position has improved, some aspects of the domestic appliance studies are approaching the final stage and the coal producers have established consumer services, thus relieving the Institute of tackling many "ad hoc" problems.

The time to resume systematic work on larger scale combustion processes has thus approached again and suitable objects of study are not lacking.

In view .../

In view of the present interest in the preparation of low-ash coal, the problem of the disposal of discards and middlings, mainly in the smaller sizes, arises, while the disposal of duff in general has plagued the coal industry for a long time.

Initial experiments could be performed with the existing facilities, but especially with regard to duff, the development and acquisition of equipment, suitable to burn this material, will become essential if further progress is to be made.

For instance, one possible method is the application of the "fluidised" combustion technique propagated by the National Coal Board of the United Kingdom. Officers of this Institute discussed this matter with employees of the Coal Board and other organisations. Opinions as to the feasibility of the method diverged considerably and suitable units could not be acquired. However, it appears that the Coal Board has made further progress and it may be possible to have tests on South African coals performed in the near future. Such an experiment would indicate whether the acquisition of a fluidised bed boiler is worth while.

Some manufacturers on the Continent produce stokers which appear to be very suitable for use with South African coals and purchase of one or more of such units might be desirable.

From time to time, the Institute receives requests from interested parties to assess the performance of hot water generators of large capacity. Because of the size of these units, such investigations have to be performed at the boiler pilot plant. Suitable staff and instrumentation has thus to be available, which supplies further motivation for keeping the facilities of the plant available in good condition.

These .../

These developments have been discussed at some length not only to underline statements made in the introduction but also to indicate that the Board's policy, as first formulated in the early fifties, was correct, even if at that time there was little general enthusiasm for such "expensive luxuries" as pilot plants.

The value of pilot plant facilities, even where large scale plant was available, has been proved.

The experience gained since the 1940ies has shown that, finally, industry places more value on the results obtained in pilot plants, simulating practical conditions, than in those obtained in smaller units that may cost less and be cheaper to run but unavoidably produce results that cannot as readily be "translated" into practice.

THE STUDY OF BRIQUETTING:

There have been various incentives for conducting research on briquetting or shaping fine coal to produce a more useful, lumpy product.

The Position in Industrial Countries.

In countries of the northern hemisphere most of the coal* mined has swelling properties, especially so in the finer size gradings. The fines arising during mining could therefore be fairly readily absorbed by the carbonisation industries (coke ovens or gasworks).

Only the lean coals and anthracite presented problems and this provided the incentive to produce a marketable fuel from fines by compressing or otherwise shaping the fuel, mixed with a binder, to a handy acceptable form.

Impressive briquetting industries were built up, e.g. in most European countries and in North America.

The .../

*In this duscussion brown coal is not considered, although most of the brown coal mined to satisfy domestic and industrial demands is briquetted. However, brown coal briquetting techniques are not applicable to bituminous coal and anthracite.

The carbonisation industries obtained a large proportion of their revenue from the recovery and sale of by-products. In fact this revenue enabled them to offer coke at reasonable prices.

Thus quite a happy balance between products arising in the coal industry and demand was established. This position was even further improved by the growing demand for finer coal size gradings by electricity generating stations during the first decades of the twentieth century. There was comparatively little wastage of usable coal produced at collieries.

The position started changing in America, even in the thirties, with the advent of cheap natural gas, and much more rapidly during World War II as the petro-chemical industry developed, replacing coal-tar chemicals more and more.

The same trend developed in Europe where, initially, cheap refinery by-products (gas and fuel oils, played the role that natural gas had played in America).

The traditional type of gasworks, based on coal, has lately practically disappeared.

The by-products from coke ovens are now more of a nuisance than an asset. They have to be recovered, however, to prevent pollution of the atmosphere or of water.

The demand for coke, both of the gasworks type and hard coke is, however, still increasing even if the specific consumption has decreased.

In practically all these countries the increased awareness of atmospheric pollution by smoke has placed a taboo on the use of bituminous coal, e.g. for domestic purposes and has frequently created a demand for quite reactive, smokelessly burning solid fuels.

Such developments provided the incentive, in these countries, to develop processes to produce on the one hand smokeless fuels and on the other hand various types of

metallurgical .../

metallurgical reductants, preferably, without generating any by-products at all.

Since in such processes, there would be only one final revenue-earning product (coke) the problem to devise a viable process has been and still is quite formidable.

Some processes for making a char or smokeless fuel, even from weakly or non-coking coal, charged to the carbonising unit in lump form, have been developed to the stage of commercial production and are finding application.

The processes suggested for the production of an alternative to conventional hard, metallurgical coke all include some "shaping" stage, usually briquetting in one form or another.

Some of these processes have reached a reasonably advanced stage of development, but there is, presently, nowhere a really sizeable semi-commercial pilot plant.

THE POSITION IN SOUTH AFRICA.

In South Africa the production of swelling coal is the exception rather than the rule.

The duff as produced can therefore normally not be considered as representing a raw material for carbonisation.

The duff problem as sketched in the previous section on coal preparation was, in a large measure, resolved later by the ability to sell pea-duff mixtures to electricity generating stations.

It is known, however, that:

1) with increasing emphasis on electric power production at pit-head stations, the stations that have been buying pea-duff or "crushed coal" from commercial collieries may progressively become 'peak demand stations" or may be completely shut down.

   The demand for power station coal from commercial collieries may thus decrease progressively.

2) The .../

2) The iron and steel industry is growing rapidly so that the demand for coke will increase substantially.

3) The steel industry is becoming increasingly aware of the advantages of coke of better quality (hardness, ash content etc.) and is, presently, especially interested in coke of lower ash content.

4) The reserves of coking coal are comparatively small. A demand for more drastic preparation to reduce the ash content may further reduce their "life"

Reserves present in some virgin areas may prove to be quite expensive to produce, prepare and make available at steel works - even if quality demands are not very severe.—

These are some of the reasons why iron and steel - and coal interests have accelerated their search for additional reserves of coking coal in recent years. The coal industry is also greatly interested in finding new outlets for duff. (The possibility of exports of such coal has been seriously considered only recently (i.e. at a later time than the period covered in this review).

The technical feasibility of recovering weakly swelling coal from the duff produced at a number of Transvaal and Natal collieries has now been established beyond any doubt.

Such swelling coal (which, incidentally, should also be attractive to the iron and steel industry because of the relatively low ash and sulphur contents) does, however, require fortification with an appreciable percentage of good coking coal to make it an acceptable coke oven feed stock.

The known reserves of coking coal may be large enough to satisfy this "fortification" demand, in respect of established carbonisation facilities, well into the near future. One is not so confident about providing the raw materials for all the additional capacity that will be needed in the next decade — should coke production continue to be based on conventional

carbonisation ..../

carbonisation practice.

This may be held to be too conservative a view, considering, for example, the optimistic views expressed in the report of the Coal Commission 1946/47, and the fact that most of the collieries producing coking coal at that time are still doing so (although a much shorter life was predicted for many of them in 1946).

However, other optimistic views, voiced at that time, for example, those in respect of the probability that substantial, additional reserves of coking coal would be discovered, have not really materialised.

Bearing this in mind, as well as the time-lag generally experienced between the finding of a solution to a problem in a research institution and its practical application, it was considered advisable, at the Institute to undertake research on metallurgical coke production from non-swelling or weakly swelling coal, which is much more readily available in the Republic, without necessarily incorporating good coking coal.

Actually, the first tentative studies in this direction were undertaken in the early forties. Work on the very small scale used was not very effective and, i.al. in view of the Coal Commission's findings and survey work initiated by the subsequently established Coal Advisory Board, the work was shelved for some years.

Then, as prospecting by the Government and by private companies did not reveal really promising reserves of coking coal while developments in the iron and steel industry proceeded apace, the matter of formcoke research was revived in the early sixties.

It may be noted that although many of the incentives that have stimulated research on substitutes for coke in America and Europe are also operative in South Africa, the main motive for the Institute's research effort on briquetting

and .../

and briquette treatment has been the position just sketched.

There have, of course, been various suggestions that, in order to combat atmospheric pollution by smoke, attention should be given to the production of smokeless fuel from bituminous coal. The Institute has prepared various cost estimates, all indicating that the cost of the product, via a briquetting stage, would be too high under present circumstances to be readily acceptable to domestic consumers of solid fuel, even if the heat treatment involved would be simpler than for formcoke.

It is also realised that reductants for electrometallurgical purposes will be needed in increasing quantity. Here again the requirements are such that the acceptable products could be made in a simpler way than formcoke. Although such "char" production was not considered as a prime reason for the proposed research, the pancake furnace installed at the pilot plant site provided a means of initiating research in this direction.

Overall, therefore, formcoke production appeared to be the more formidable problem. If it could be solved, know-how would have become available to deal expeditiously with the other problems should the need for such studies arise.

It may be held that such development work should be allowed to proceed elsewhere. This country could then, in due course, buy the know-how.

However, at the end of the fifties little was being done elsewhere, specifically with formcoke in mind. The term "formcoke" had not even been coined. Since that time various organisations have been active in research. However, there is no great urgency to find a solution, as in those countries the raw materials for conventional coke production are available in adequate quantity — albeit often at quite a high price.— The acceptance there of any formcoke process depends on the proof of substantial economic advantage over the conventional processes — which, by the way, are also being improved to

make .../

make them more viable.

ACTION DURING THE PERIOD 1960/70.

Accepting that briquetting would be an essential step in the conversion of non-coking coal into formcoke, laboratory work on briquetting was again started at the beginning of the sixties.

Somewhat improved equipment was used but operations were largely manual. However, it enabled officers to get some feel of the problem.

This apparatus was later used by bursurs of the Institute studying at Potchefstroom and enabled them to study some operating variables. It had to be realised, however, that the results obtained were more of academic than of practical interest.

Therefore officers of the Institute visited Europe in 1964 to make a fairly detailed study of briquetting practice and of available pilot plant, with emphasis on pilot plant that could yield results having the greatest practical significance.

The reports submitted by these officers were considered by the Pilot Plants Advisory Committee and the Fuel Research Board, and the Institute was authorised to acquire some basic equipment viz.: a briquetting roll-press (capacity about 2 t.p.h. max.), a mixer and some ancillaries. These were actually bare necessities.

This skeleton plant was housed, for the time being, within the boiler house at the pilot plant site where it could be accommodated as the boiler was temporarily not in use.

Considerable manual work had to be done when operating this plant. It could handle about 200 lbs. of mixture per batch. With experience and good organisation three to four batches could be treated per hour.

After some experience had been gained in the operation of the plant the Fuel Research Board agreed to send an

officer .../

officer overseas for a more detailed study of briquetting practice and research as well as of the heat treatment of briquettes.

The officer was able to work for some 6 months at the Bergbauforschung laboratories in Essen and then paid visits to other centres.

Very valuable experience was gained. From the experience gained at the research institutions, deficiences in the Institute's skeleton plant could also be pin pointed.

The officer was also able to study the pelletizing process which might serve as an alternative shaping process.

From 1968 onwards most of the initial problems encountered with the skeleton plant were solved and quite smooth operation was obtained.

Although deficient in many respects, the plant has more than justified its acquisition. It has enabled the Institute's staff to gain valuable experience.

The Institute has been approached by many organisations, some with no connection whatever with the coal industry, to briquette diverse powdery materials. Assistance was rendered wherever possible excepting cases where the material to be treated was deemed to have too strongly abrasive properties. The Institute could not afford to damage the roll-press irreparably.

The work done for Iscor in connection with Iscor's research on formcoke is of greater significance than the other services rendered. In this case staff of Iscor's pilot plant centre prepared mixtures which were briquetted in the skeleton plant either for further studies at Iscor's centre or carbonisation in the Institute's experimental coke ovens. Such pilot plant carbonisation tests, for example, preceded experiments in which Iscor charged briquettes into full-scale ovens.

The .../

The decision by Iscor to undertake such larger scale carbonisation experiments provided the first incentive to improve the briquetting facilities. This was also considered necessary to improve the uniformity of products.

Finally, as basic briquetting know-how had now been attained, consideration would have to be given to the next step in formcoke production viz. heat treatment or carbonisation. In order to ensure the smooth operation of any carbonisation unit a reasonably steady production of briquettes would be necessary (or an adequate stock of briquettes would have to be provided).

Thus, to improve uniformity it was deemed to be necessary to provide better pretreatment facilities for coal and the binder, (crushing, drying etc.). A more efficient kneader and better temperature control in it, as well as a conditioner unit between kneader and press to equalise temperatures and ensure a more even feed-rate to the press, would also be essential.

For continuous operation one would need, in addition, storage facilities for raw materials and products, feeders, conveyors etc. Such a plant could no longer be accommodated in the boiler house. A new building would therefore have to be provided.

This, broadly, was the line of thinking discussed by the Pilot Plants Advisory Committee in 1968/69. (Actually, also at least one carbonising unit was incorporated in the tentative plan.)

A scheme of this nature was tentatively supported by the Pilot Plants Advisory Committee. The only criticism raised was that such a unit with a possible normal output of 20 t.p.d. or a maximum of 30 t.p.d. might be too small to provide enough formcoke in a reasonable time to allow blast furnace tests of adequate duration to be done.

It was .../

It was finally agreed, however, that this would be an experimental tool not necessarily to be used to provide the final answer required by the blast furnace operator.

It was considered at the time, that, if such facilities were available, a joint programme with Iscor and coal interests could be planned.

With this in view, Iscor and the coal industry might be prepared to assist financially to provide the plant.

Although Iscor had also started on formcoke research, the representatives of the corporation on the Committee raised no objection to the proposed plant as constituting a duplication of facilities. The impression was gained that it was rather regarded as supplementary to anything that Iscor was planning, or had installed at its pilot plant. The only misgiving or doubt expressed was, as already stated, that the plant might not be able to produce the quantity of formcoke needed for large scale testing.

Accordingly, this planning was submitted to the Fuel Research Board for consideration. The Board resolved that a formal approach to Iscor and the coal industry for financial assistance was warranted.

However, before any formal negotiations could be initiated, the Institute was informed by Iscor that the corporation had resolved that it would acquire considerably larger facilities for briquette production and would therefore not consider assistance to finance the Institute's pilot plant.

The Fuel Research Board, therefore, resolved to keep the initiation of negotiations in abeyance but that general planning could proceed.

THE .../

THE FINAL PLANNING ON THE CONSIDERATION OF ESTIMATES OF CAPITAL REQUIREMENTS.

In the course of planning, during 1969 and 1970, for the mechanisation of the briquetting plant and for making it suitable for continuous operation, the basic requirements were established and various lay-outs were considered.

Tentative proposals were discussed with representatives of firms and also, extensively, with officers of Iscor, representing the Corporation on the Pilot Plants Advisory Committee, and others concerned with Iscor's formcoke studies.

In addition to valuable general comments made, the gentlemen consulted drew attention to some desirable alternatives such as providing facilities for adding binder to the coal either as finely ground solid or in the molten state.

The attention was also drawn to specific types of equipment which, by corresponding more closely to the units to be installed e.g. in Iscor's semi-large-scale plant, might be given preference so as to ensure that pilot plant results could more easily be interpreted in terms of the larger scale practice.

Having obtained reasonable finality on the lay out, attention was given to the housing of the plant. In the design of the building, provision was made for a reasonable control laboratory for routine testing of raw materials and the briquettes produced.

The proposed plant is described in Technical Memorandum No. 26 of 1970. Provision was made for as much flexibility and versatility as possible so that the plant could serve to study briquetting under a variety of experimental conditions.

Quotations were invited for individual items of equipment from a number of firms. Often the response was poor, but reasonable quotations were received in many cases. The quoted prices for some items were so high, however, that the

offers .../

offers could not be considered. Adequate replacements for some of these items could probably be manufactured in the Institute's workshop at a much lower price.

The 1970 estimates already contained recommendations for the purchase of some items of equipment as well as for the building. This expenditure was approved by the Fuel Research Board.

Some provision was also made in this estimate for development work on a carbonising unit and this study will proceed in 1971. It may lead to the development of an alternative carboniser to the existing equipment (experimental coke-ovens and the pancake furnace).

By September, 1970, enough quotations for most items of equipment had been obtained so that a more complete estimate of capital requirements could be submitted to the Pilot Plants Advisory Committee than in 1969.

Even when leaving out of account the extremely high priced items for which substitutes could probably be found and others which might be manufactured at the Institute, the final estimate for 1971 was rather high at R75,000

At the meeting of the Pilot Plants Advisory Committee, considering estimates for 1971, a number of items were queried. During the ensuing discussion, representatives of Iscor confirmed that items such as the Wibau mixer and ancillaries, although expensive, should if possible, not be excluded.

The committee finally accepted that no unnecessary items had been included in the lay out.

Nevertheless, the committee finally recommended approval of the expenditure to the Fuel Research Board with some reluctance as this was responsible for reducing the balance in the Pilot Plants Conservation and Development Fund to only R15,444.

It was .../

It was tentatively suggested to the Fuel Research Board that, in view of this undesirable situation, consideration might be given to approach Iscor and the coal industry for financial assistance.

The Fuel Research Board subsequently approved the estimate but at the same time resolved that the possibility of financial assistance from Iscor and the coal industry should be investigated.

A MOTIVATION FOR FURTHER RESEARCH ON FORMCOKE PRODUCTION.

Considering this review and the recent developments in the formcoke field, the question must now be posed:—

Even accepting that the initiative taken by the Institute to start briquetting and formcoke studies is entirely justifiable —

"Is an expansion of facilities or even further research on this subject at the Institute justifiable in the seventies?"

Facts that have to be considered appear to be:

1. Iscor as well as coal mining companies or their selling organisations have sent samples of coal overseas to be investigated with formcoke production in mind.

2. After doing research of its own (assisted frequently by the Institute) Iscor has acquired a briquetting plant with a design capacity of some 100 tons per hour, clearly to produce briquettes at a sufficiently rapid rate to build up sufficient stocks of "formcoke" for adequate blast furnace tests, in a reasonably short time.

3. It is not known to the Institute whether or not briquetting or formcoke work on a pilot plant scale is contemplated by individual coal mining companies or their selling organisations. From passing remarks made at the last Board meeting it will be assumed, for arguments sake, that this is in fact the case.

Now .../

Now, work on a fairly ambitious pilot plant scale is a necessary step between smaller scale research and development work and commercial production. It is, however, generally undertaken only after sufficient research and development work on a smaller scale has been successfully concluded.

Seen in this light the following conclusions could be drawn from the above statements:

(a) The officials of the companies concerned, who were responsible for studying processes overseas, concluded that the "state of the art" was not sufficiently advanced to prove the viability of a process conclusively. Therefore it would not be possible to order a commercial plant forthwith.

(b) Nevertheless, it may have been concluded, sufficient information is available from either the own research or from this and the research of others, to embark directly on the final proving (larger pilot plant) stage.

(c) Alternatively, the decision to erect larger pilot plants may result from a sense of urgency to find a solution to the problem of providing an alternative to the conventional coke production processes, either to ensure the continuity of supply of an essential raw material (this may largely be Iscor's incentive) or to utilise the financial benefits potentially accruing from the possession of the know-how of a really viable process. Such urgency may justify the risk taken in embarking on larger scale studies even if certain basic information is lacking.

(d) Whatever the incentive or incentives, the decision to undertake pilot plant work on a fairly large, to large scale, creates the possibility of commercial production in the near future.

It may, therefore, be held that it is unnecessary to continue with less ambitious, smaller scale research projects.

The Institute .../

The Institute could not subscribe to such a view.

Drawing on the knowledge derived from its survey activities and its research on the carbonisation of South African coals as well as on the experience gained with existing pilot plant facilities - proved i.al. as a most useful adjunct to commercial plant - it recommended research on formcoke because:-

(i) Taking the longer range view - appropriate to a research centre - it is considered to be essential to develop an alternative process to produce acceptable metallurgical coke - ultimately from entirely non-coking coal.

(ii) In addition to laboratory research, work on a pilot plant scale would be necessary to provide practical proof of the technical feasibility of any process and to gain practical experience in the handling and operation of semi-commercial plant.

(iii) The scale of operations should be selected to provide practical and meaningful data while still being modest enough to keep operational costs at a level that the Institute could afford. —

The fact that companies may now erect larger pilot plants and that commercial production of formcoke may soon become a fact in South Africa, do not affect these recommendations materially.

The reasons for making this statement are set out under the headings:

A. The Need for Further Research and
B. The Value of Relatively Small Scale Pilot Plant.

A. <u>THE NEED FOR FURTHER RESEARCH</u>.

Should various companies have decided to erect pilot plants, the decisions are interpreted as additional proof of

the urgent .../

the urgent need to do research and development work in this field.

Iscor naturally has a vital interest in the matter.

The Corporation's research led to the development of a technique (described for example in "Iscor News" - Sept,1969 - "Iscor Produces Formcoke") that would enable the Corporation to do the carbonisation step in conventional coke ovens.

This is, an important development.

There is, therefore, no suggestion of belittling the achievement by describing the proposed process as an "interim solution" to the formcoke problem, however important it may be during the next decade or two. In fact, Iscor by its own action - of continuing with relatively fundamental research and of expanding pilot plant facilities - subscribes to such a view of its present formcoke process, based as it is, according to published information, on some degree of swelling properties in the coals used.

The Institute does not profess to have, as yet, expert knowledge of every phase of an ideal formcoke process. Its probing, - however imperfect at this stage - nevertheless, suggests that even in the briquetting stage - which is, in principle, quite a "standard" process and probably one of the simplest steps in the sequence for formcoke production.- much remains to be done to achieve optimum conditions in the South African situation.

Although overseas laboratories have advanced considerably in their research, it appears obvious, from the present efforts made by South African companies, that their present knowledge does not provide all the required answers.

Possibly the most crucial step in formcoke production is that of the heat treatment or carbonisition of briquettes. The final solution (both technically and economically) has yet to be found. Iscor will have to establish

whether .../

whether, in fact, conventional coke ovens can generally be used. In Germany, where the raw materials for "hot briquetting" are available it may be proved that with briquettes prepared in this way, a final carbonisation treatment is unnecessary. So far this does not hold for briquettes made in the conventional way.—

The fact that Iscor may intensify its research and development effort, does not rule out work at the Institute. The Corporation's laboratories and the Institute have been working side by side for many years. Their efforts have been supplementary and frequently incitive from one to the other. In many respects the Institute's facilities have been of fundamental importance in Iscor's development work. Whenever required the assistance has been rendered unstintingly.

The approach between a research and development laboraotry of a private company on the one hand and that of the Institute on the other hand differs in that the one operates practically exclusively in the interests of its company, whereas the Institute's general approach is towards "national interest research". Its facilities and know-how are available generally. Fundamental knowledge and expertise gained by the Institute may be made known, or placed at the disposal of any one interested. It is, however, also applied in efforts to solve particular "private interest" problems referred to the Institute by a sponsor. In this case the sponsor gets the answer to his particular problem - and nobody else, except with the sponsor's permission. Some concerns may not like the "free for all" part of this policy; yet they have scored handsonely by being able to call on South African expertise from a neutral or "uninterested" institution when seeking a solution to certain problems.

Therefore, it is concluded that there is ample justification for continuing the research effort and that the

Institute .../

Institute can and should participate in the research for the ultimate benefit of consumers and producers of, in this case, coal and coke.

B. THE VALUE OF RELATIVELY SMALL SCALE PILOT PLANT RESEARCH.

Larger scale pilot plant studies have the great advantage of providing more reliable technical and economic data than laboratory and even small scale pilot plant work can yield. They also provide the possibility of quite readily making available stocks of product for testing in the appliances in which that product is to be used, e.g. blast furnaces.

However, as the size of the pilot plant increases it becomes more rigid in many respects. Individual items of equipment become progressively more expensive and are, therefore, not lightly duplicated or, later, replaced by possibly more efficient units. The large unit is ideally suited to long runs under specific conditions (which are largely dictated by the choice of plant or individual units originally incorporated in the design).

In the briquetting stage, it is quite conceivable that experiments on the effect of variations in binder quality and dosage, and the composition of the coal types used could be done. Nevertheless, the scope of such studies will tend to be limited because of the tonnage of materials involved and the cost of running the plant in general.

Hence, the contention that a large pilot plant is in the nature of a "proving" rather than an experimental unit.—

The small scale plant has the advantage that a great deal of flexibility can be built into it from the outset at no excessive cost. This may apply to the type(s) of preparation plant for coal and binder(s) the method of addition of the binder to the coal and of the mixing and conditioning

process .../

process applied before feeding the mixture to the press. It can naturally also apply to the briquetting procedure and would preferably be applied to any final heat treatment stage.

The running costs and the amount of raw materials required to complete a meaningful run are relatively so low that fairly exhaustive experiments to establish the effect of variations in operating conditions can be undertaken without exceeding a reasonable budget.

The scope in the choice of raw materials used is thus also widened.

Admittedly, a small pilot plant is a research tool rather than a producer of "commercial quantities" of products.— Nevertheless, it is submitted, the disadvantage of not being able to provide products readily for large scale testing is more than outweighed by the advantage of covering a wide field of interest at a reasonable cost. The above disadvantage would actually become negligible if larger scale pilot plant — or commercial plant — is available in the country, even if this plant does not conform in all respects to the "desirable" design indicated by the experimental work.

It remains to consider the location of such a small scale pilot plant.

It is of interest to note that many appliance manufacturers do not possess pilot plants of any dimensions to serve as demonstration models of the process(es) offered. Quite frequently they may install such a facility at a research centre to which they can refer clients.

Under certain circumstances a company, be it the appliance manufacturer or the company interested in applying the process, may erect a pilot plant.

In these cases the plant is generally used for a very specific purpose and when it has served that purpose it

becomes .../

it becomes redundant. The Institute has benefited on more than one occasion because of such redundancy, being offered plant either on "permanent loan", as a donation or at a nominal price.

Only companies having extensive research and development departments may retain such plant either as operational models or broken up into items of "unit operations equipment" that can be assembled ad lib. to provide the same or other pilot plant facilities.

With these exceptions, pilot plants are usually found in research institutions where they have a more permanent function and value.

The staff of such an institution may use the pilot plant to do research on matters, seemingly of no particularly vital interest to any one company at any specific time. Yet, the accumulated knowledge and the experience gained greatly assists in solving problems posed by industry on another occasion.

One is often inclined to stress the value of any research facility as "a fact finding tool". Considering pilot plants, the opportunity offered to train personnel on semi-commercial machines and to help them to acquire expertise in the technique and confidence in tackling a problem on a larger scale plant is, at least, as important if not more important to the industries served.

Therefore, it is held that the investment in pilot plants at the Fuel Research Institute has paid handsome dividends to the coal industry and Iscor and will continue to do so provided that these industries enable the Institute to acquire the basic equipment required to study new techniques on a reasonable scale.

(SIGNED) A. J. PETRICK.

DIRECTOR.

PRETORIA.
12/2/71.

S U M M A R Y.

In the introduction of this report the theme is developed that, in order to render maximum service to industry a research centre such as the Institute should, in addition to any studies of immediate interest, plan for and do research on problems that are likely to be posed in the future. This would include the study of technologies not yet applied. Such readiness to tackle problems is achieved by accumulating knowledge and by becoming conversant with equipment and techniques used and likely to be used by the industries served. Hence fundamental and applied research both in the laboratory and in pilot plants is necessary. (Pages 1 - 3).

An attempt is then made to show how this philosophy has developed from experience at the Institute.

The early (1931-1940) studies, especially on coal preparation and carbonisation are outlined. (Pages 3 - 4).

The period (1940-1958) is reviewed. During this period, laboratory studies were extended to some bench-scale research and also attempts to conduct studies on equipment installed at collieries. Although the results were frequently not really satisfactory the contact with practical engineers and the experience gained created sufficient confidence to induce the industry to call on the institute's staff to assist in solving coal preparation problems, and later to carry out acceptance tests on new plant.

The idea of erecting a coal preparation pilot plant was conceived mainly because of the difficulties experienced with bench-scale work and research on colliery plant. The planning for and the erection of the plant were completed in 1958. (Pages 4 - 8).

Since .../

Since 1958, after an initial period during which very little interest was shown in the pilot plant facilities, the number of assignments to wash coal, and to provide other assistance grew steadily.

The experimental coke ovens, erected in the early sixties have also been in increasing demand by Iscor and coal producers. During the past two years practically only contract work could be done in these pilot plants. (Pages 8 - 11).

Some pilot plant facilities for studies on the combustion of coal have also been provided, but, during the last 4 - 5 years combustion research was largely devoted to the development or testing of smokelessly burning domestic appliances. (Pages 11 - 13).

From the early 1940ies, but especially since 1964, attention has been given to the possibility of finding an alternative process to make metallurgical coke (smokeless fuels and "char" production were not prime objects of these studies).

Small scale laboratory work to make briquettes proved to be quite inadequate and finally a skeleton briquetting plant was provided. This set up, still requiring considerable manual work, could produce up to 800 lb. of briquettes per hour. Mechanised, it has a potential throughput of some 2 tons per hour.

The present planning is to mechanise the operations. Thereby a greater uniformity in the product and a steadier production rate will be achieved. This would be essential when the next stage in formcoke production - carbonisation - is to be studied. — Pages 14 - 26)

In the last section of the report the questions, whether further research is desirable and to what extent the Institute should be involved, are discussed.

It is concluded that further research is necessary

and that .../

and that the Institute has an active role to play. (Pages 26-33).

The Motivation for the Institute's Present Planning can be Summarised as follows:

A. The Situation in South Africa.

Because of the relatively small reserves of coking coals, South Africa must be more vitally interested in formcoke than the industrial countries still having large reserves of coking coal.

(Since char for electro-metallurgical purposes is already made from non-coking coal and the cost of making smokeless fuel from bituminous coal still appears to be too high to be competitive, the highest priority must be given to formcoke studies.)

B. What is the Aim.

It is, therefore the Institute's main object in this planning, to study aspects of formcoke production — ultimately from entirely non-coking coal.

C. Proposed Research.

(1) Since the ultimate object is to use non-coking coal as raw material, a briquetting stage appears essential in the formcoke process.

The attention has, therefore, been concentrated on briquetting in the first phase of the research programme.

(2) From experience gained in laboratory bench-scale studies it appears to be essential to do the research on, at least, a modest pilot plant scale. This plant should be as flexible as possible.

(3) Although .../

(3) Although briquetting of coal with added binder is an established technique, it is already clear that briquettes, used as formcoke raw material, need to have special characteristics so as not to spall or disintegrate during the final heat treatment at high temperature. It is a prime object of the research to try and establish the essential criteria and how they can be "built into" the briquettes.

(4) As far as can be foreseen pitch bound briquettes from non-coking coal will have to be converted to formcoke by some heat treatment.

Orientative heat treatment studies may be done using available equipment and some development plant.

(5) In a later phase of research the attention may be concentrated on the heating or carbonisation stage.
