PROCESS CONDITIONS FOR PRODUCING A
SMOKELESS BRIQUETTE FROM HOT CHAR

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1. INTRODUCTION

In the United Kingdom the implementation of the Clean Air Act of 1956 involves the setting up of an increasing number of smokeless zones throughout the country. In order to maintain sales of solid fuel, appliances to burn the present fuels smokelessly are being developed, and increased supplies of reactive smokeless fuels are being made available. To contribute to these supplies, a process for the production of a smokeless fuel from low rank coal has been developed at the Coal Research Establishment of the National Coal Board. A general account of this development has recently been given in another paper(1), and it is proposed here to review in detail some of the investigations which were carried out to determine the range of application and necessary process conditions.

The choice of low rank coal, volatile content greater than 35%, as a starting point is particularly appropriate in the U.K. as this material in small size gradings is economic to mine and well situated with respect to the markets.

To convert this material into a suitable smokeless fuel requires that it be both upgraded in size and rendered smokeless, without markedly reducing its reactivity. It was known(2)(3) that low rank coal could be made smokeless by a process of partial carbonisation and it was thought likely that considerable reactivity would be retained in the char.

It was decided to attempt to briquette the char in the simplest possible way, i.e. without a binder of any kind. All attempts to briquette cold char using pressure alone have proved unsuccessful, but several attempts to briquette char when hot had shown promise.

Thus in 1931 Hardy(4), working in Belgium, took out his first patent on the hot briquetting of char and several more were filed, the last in 1937. The first Hardy patents cover a process which was intended to briquette finely divided coals and lignite; the raw coal was heated in a rotary oven to a 'plastic or globulated state', and compacted directly on discharge. The tars generated in the carbonisation process were claimed to act as binder.

Hardy's process was not a commercial success and in a much later assessment by Darmont[5] this was attributed to difficulties arising in the production of char under controlled conditions; agglomeration was a big problem. Similar difficulties seem to have been encountered by Piersol in his work in Illinois[6][7].

Interest in the briquetting of hot char was reawakened by Jappelt in 1952[8], who gave an extensive, though largely qualitative account of the factors involved in successful char briquetting. His work is of particular interest in that he concentrates on weakly caking coals, uses a rotary oven for preparing the char and advocates the use of an extrusion press for compaction.

In the light of these earlier investigations, the line of investigation adopted was to prepare the char under controlled conditions, and briquette it whilst still at a high temperature. This paper sets out to establish the process conditions for making a strong smokeless fuel from high volatile weakly caking coals by this method.

The strength of any compact produced by the direct briquetting of hot char can be expected to depend upon the following factors:-

1. The nature of the raw material.
2. The carbonisation conditions.
3. The compaction conditions.
4. The after-treatment or cooling of the briquettes.

It is not proposed in this paper to consider all the process variables, even if this were possible, but rather to focus attention on those which have been found to be the most important.

The paper first describes some of the laboratory investigations carried out under 1, 2, and 3 above, and later reviews these in the light of experience on a continuous plant. An account is then given of the necessary quenching conditions obtained from plant investigations. Finally after a brief sketch of the present state of the process a summary of the main findings is given.

2. LABORATORY INVESTIGATIONS

2.1. Description of Apparatus

The laboratory experiments were concerned with determining the conditions for the production of a strong briquette from char. It was not practicable to examine the conditions for the production of a smokeless product on this scale as insufficent product was available for test.

Fine coals (-10 mesh B.S.S.) of N.C.B. Coal Rank Classification Nos. 700, 800 and 900 (high volatile bituminous coals of low caking power) have been used; in coals of this type a reduction of volatile matter content to about 23% is sufficient to produce a completely smokeless char.

Preliminary experiments were conducted by heating a small briquetting mould (½ inch diameter) to temperatures in the low temperature carbonisation range (375-500°C) and introducing small charges of fine coal. After heating this material for about 5 minutes a plunger was introduced into the mould and the char was briquetted between the jaws of an hydraulic press. Strong compacts could be made in this way but this method of heating was not practical for commercial exploitation and, as the temperature of the material was not uniform, accurate temperature measurement was not practicable.

Experience at this research establishment had shown that low rank coals (CRC.700, 800 and 900) could be carbonised in this range with considerable accuracy of control using a fluid bed carboniser: the agglomeration problems had been overcome. Accordingly, a small laboratory reactor two inches in diameter was constructed which operated on a batch principle. In this reactor a coal charge could be loaded and carbonised at any temperature up to 550°C for any desired time. The char produced could be fed directly into a preheated mould and briquetted at any desired pressure.

The apparatus developed, which is illustrated in Fig. 1, was made up of the 2 inch fluid bed reactor which could be discharged into a 0.6 inch (dia.) heated mould held in the jaws of an hydraulic press. Fluidisation was normally carried out using nitrogen preheated to the chosen temperature of carbonisation and introduced into the base of the bed via the briquetting mould. Other fluidising gases, or mixtures of gases, could readily be substituted for the nitrogen flow. Control of the bed temperature was carried out by external heating and cooling coils wound round the reactor.

In operation both the reactor and the mould were first raised to the carbonisation temperature with hot nitrogen flowing through the system. A coal charge was then loaded into the carboniser and the heaters adjusted until the carbonisation temperature was reached: this took 2 to 3 minutes and thereafter the temperature was closely controlled (± 5°C) for the required carbonisation time. At the end of this period the fluidising flow was stopped, and the distributor plate opened to allow char to fall directly into the mould. The char was then briquetted. To prevent any surface oxidation each briquette was allowed to cool in a small closed container.

2.2. Testing Methods for Laboratory Samples

The quality of the briquettes was assessed by a destructive mechanical test. This consisted of a combined shatter and abrasion test in which single briquettes were first subjected to a standard abrasion treatment in a commercial abrader. The +⅛ inch material from this test was then dropped four times through a height of 6 ft., and the residue of + ¼ inch material weighed. This was expressed as the percentage of the weight of the initial briquette. The index so formed was regarded as a purely relative measure of briquette quality. In some experiments the density of the briquettes was determined before the destructive test.

2.3. Results of Laboratory Work

2.3.1. Nature of the Raw Material:

Whilst initial tests carried out with a single coal quickly confirmed that strong compacts could be made by heating the coal to temperatures in the range 375°C - 550°C andcompacting the char at 6 ton/sq.in., it was necessary at an early stage to know whether the process would be applicable to a wide range of low rank coals.

Samples of small coal, from six different collieries situated in the East and West Midlands divisions of the Board were selected and briquetted using carboniser temperatures between 375° and 475°C. The coal was ground to -10 mesh B.S.S., and the total residence time in the reactor was 8 minutes and the briquettes were made at a pressure of 6 ton/sq.inch.

The results of shatter and abrasion tests on these briquettes are shown in Fig. 2. Despite the fact that the samples ranged over different coal seams, had widely different ash contents (2 - 16%), and covered a volatile matter content range of 35 - 41% (see Table 1), the difference in briquetting performance between these samples was not significant.

In a later attempt to briquette as wide a range of materials as possible, special maceral concentrates, prepared from a low rank coal by hand selection, were also examined. These covered a much wider range of materials than would ever be expected to arise from normal commercial preparation of low rank coals. It was found[9] for example that it was necessary to have inertinite concentrations of 60–70% before an unbriquettable material was obtained.

Size of grind can also be expected to affect the strength of char briquettes. Laboratory experiments have indicated that strength falls with increasing particle size.

To summarise, there is wide tolerance in the type of low rank material selected for the process provided that the material is crushed to a suitable size before briquetting (-10 mesh B.S.S. would appear adequate).

TABLE 1

Laboratory investigations of different coals - Details of coals used

Coal Sample			Gray-King Coke Type	Ash Content % (dry basis)	Volatile Matter Content % d.a.f.
Division	Colliery	Seam			
East Midlands	Bestwood	High Main	B	7.2	38.1
"	Calverton	High Main	A	11.7	36.8
"	Denby Hall	Mixed	C	16.5	37.8
"	Thoresby	Top Hard	D	10.9	35.6
West Midlands	Birch Coppice	Mixed	B	11.1	41.2
"	Dexter	Mixed	A	1.7	38.0

2.3.2. The Carbonisation Conditions

The results already obtained for different coals (Fig. 2) also show that at a residence time of 8 minutes the best briquettes are produced at a temperature of about 425°C.

The general effect of carbonisation variables on briquette quality may now be considered. Using fluid bed carbonisation the major variables can be considered to be the temperature of operation, the residence time of material in the reactor, and the nature of the fluidising atmosphere. In all these laboratory experiments the residence time was measured from the instant of loading the charge and thus also includes the heating-up period of 2-3 minutes.

These carbonisation variables were examined in two experiments. In each case Calverton coal C.R.C. No. 902 was used.

In the first of these an inert atmosphere (nitrogen) was used, briquettes being made over a range of temperatures from 350°C to 500°C and a range of residence times of 5 min to 80 min. Three replicates of this experiment were made, each replicate being suitably randomised.

The variation in density with temperature and residence time is shown in Fig. 3, and that of mechanical quality as given by the combined shatter and abrasion test in Fig. 4.

It may be seen that both mechanical quality and density are a maximum in the temperature range 400–450°C, and that both decrease with increase in residence time.

In Fig. 4 contours are included to show the residual volatile matter contents (dry ash free) of the briquettes. These indicate that the best briquette quality is achieved about the 30% volatile matter content, but that strong briquettes can be produced down to and below a 25% volatile matter content, at which level very little smoke emission would be expected.

Having established that it was possible to produce briquettes using an inert atmosphere in the carboniser, a second experiment was undertaken to test the effects of using other atmospheres. In all cases the same fluidising flows were maintained, and the atmospheres selected were:-

(i) Nitrogen as with the previous experiment.

(ii) Nitrogen/hydrogen mixture (90:10 parts by volume).

(iii) Steam.

(iv) Air/nitrogen (50:50 parts by volume).

The latter atmosphere was of particular importance in that in a continuous commercial reactor it was likely that the carbonisation heat would be obtained by heat of reaction, and air would be used as a fluidising gas. In the small reactor used, with the cooling coil working at maximum capacity the air/nitrogen mixture was the richest which could be used: at higher oxygen concentrations control was impossible.

With these atmospheres briquettes were prepared in the temperature range 400° to 500°C using residence times of 8 and 16 minutes. The results are given in Table 2. For all the atmospheres, the temperature range for good briquetting was found to be substantially the same, and the fall in quality with increasing residence time was confirmed. It may be seen, however, that briquette quality was significantly reduced when the air/nitrogen mixture was used for fluidising.

From these investigations it is clear that to produce strong briquettes long residence times in the carboniser must be avoided; briquettes must be made in a limited optimum temperature range, and reactions with oxygen in the fluidising gas must be kept to a minimum.

TABLE 2

Variation of Briquette Strength* with Fluidising Atmosphere, Carbonisation Temperature and Residence Time. (Laboratory Results).

Fluidising Atmosphere	Residence Time (min)	Carbonisation Temperature °C				
		400	425	450	475	500
Nitrogen	8	95	94	97	96	92
	16	92	95	94	94	53
Nitrogen/Hydrogen 90:10 parts (vol.)	8	92	97	96	96	95
	16	92	93	94	91	80
Steam	8	86	96	96	94	83
	16	81	92	93	88	38
Air/Nitrogen 50:50 parts (vol.)	8	85	89	91	87	83
	16	76	84	86	72	22

* Figures given are the percentages of +¼" material remaining after test.

2.3.3. The Compaction Conditions

It was mentioned in the introduction that char cannot be briquetted cold, and in the experiments so far described, care has been taken to maintain the briquetting mould at the carboniser temperature. Such a procedure may however be inconvenient on plant, and consequently a short investigation was made of the effect of cooling before briquetting. In this experiment briquettes were made using a single coal (Calverton C.R.C. 902) carbonised at 450°C for 15 minutes. After this period the char could be cooled to any desired temperature by switching over to cold nitrogen as fluidising gas, cutting the bed heaters, and turning on the external cooling. When the desired temperature drop had been achieved the char was then transferred to a mould maintained at the reduced temperature and briquetted (in this case at a pressure of 8 ton/sq.in.).

The results of the strength tests are shown in Fig. 5 where it can be seen that whilst quality falls slowly with temperature down to a temperature of about 250°C, after this point it falls rapidly.

The actual variation of compaction density with pressure is shown in Fig. 6, and it can be seen that at 6 ton/sq. inch the compaction curve is already becoming very steep at the temperatures involved. Pressures of 6–8 ton/sq. inch have proved adequate for all the coals studied both in laboratory and plant experiments.

3. SMALL SCALE PLANT INVESTIGATIONS

3.1. Description of Plant

A description of various experimental plants for the production of briquettes by this process has already been given elsewhere(1), so that it will only be necessary to add a brief description here. The particular plant used for most of these investigations was a small one capable of handling 100 lb coal/hour, Fig. 7. The reactor was 8 in. in diameter and was continuous in operation. Coal was fed into the vessel by screw feeder and char was withdrawn through a conical base to avoid agglomeration difficulties. It was normally run with cold air as the fluidising gas, all the process heat being derived by reaction with the coal.

Briquettes were made on an hydraulic extrusion press which normally produced a cylindrical compact 2 inches in diameter, and 1⅜ inches long, this size being very suitable for domestic grates. With the limited plant throughput this size of briquette implies a briquetting rate of about 8 briquettes per minute, and thus speed of briquetting was low by commercial standards.

3.2. Testing Methods

As appropriate to this plant quality was assessed by larger scale tests, these consisted of:

(i) Shatter test - 10 lb. of product was dropped four times through 6 ft. on to a steel plate, and the weight percentages of +1 inch material determined; and,

(ii) Abrasion test - 5 lb. of product was subjected to 625 revolutions at a standard rate (25 r.p.m.) in a smooth steel trommel, the weight percentages of the resulting +½ inch material being determined.

For brevity in this paper the results of these separate tests have been combined in a single strength index by forming the product of the indices. This single strength index then bears some resemblance to the combined shatter and abrasion test results obtained from the laboratory investigations. Whilst the strength tests were intended for relative assessment of the product it is considered that where the index obtained exceeded 80% the briquettes would transport well, whereas if it was less than 50% they would transport badly.

3.3. Results of Plant Work

In the following review of the effect of process variables the product has in all cases been dry cooled (i.e. allowed to cool in sealed drums). On a full scale plant cooling in sealed drums would not be possible and development of briquette quenching methods is described later in section 3.3.4.

3.3.1. Nature of the Raw Material

Low rank coals from 24 different collieries were examined covering the range of Gray King coke types A to F. Using a temperature of 425°C and a residence time of 20 min, it was found possible, in all cases, to produce strong briquettes (i.e. combined shatter and abrasion index greater than 80%, see Table 3). At this carbonising temperature the smoke emission of the briquettes, as shown by tests in an open grate, was small in all cases.

TABLE 3

Plant investigations of different coals
Details of coals used and the strength of briquettes
Produced at 425°C

Coal Sample			Gray King Coke Type	Ash Content % (dry basis)	Volatile Matter Content % d.a.f.	Strength of bqs. made at 425°C (%)
Division	Colliery	Seam				
E.Midlands	Babbington	Deep soft	F	2.1	37.2	91
"	Thoresby	Top hard	F	5.2	35.3	93
"	Rufford	Top hard	E	4.9	37.7	93
"	Welbeck	Top hard	E	4.8	35.5	92
"	Babbington	Deep hard	D	3.1	35.9	92
"	Gedling	Top hard	C	6.0	38.8	92
"	Radford	Tupton	C	3.1	37.8	93
"	Shirebrook	Clowne	C	4.0	37.1	92
"	Whitwell	High Hazel	C	4.0	35.6	91
"	Bestwood	High main	B	7.5	37.8	91
"	Bestwood	Main bright	B	1.5	38.5	92
"	Gedling	High Hazel	B	6.5	39.8	93
"	Ollerton	Top hard	B	5.2	37.9	90
"	Warsop	High Hazel	B	9.1	36.3	91
W.Midlands	Coventry	Mixed	C	1.9	39.4	91
"	Haunchwood	Mixed	B	5.6	40.7	90
"	Newdigate	Mixed	B	2.9	39.1	92
"	Arley	Mixed	A	5.0	39.2	91
"	Dexter	Mixed	A	4.2	36.8	89
N.Eastern	Kiveton Park	High Hazel	F	2.7	36.1	87
"	Markham Main	Barnsley	D	3.8	36.8	90
Scottish	Dalkeith	Barrs	C	5.0	41.0	89
"	Dalkeith	5 ft	C	4.8	40.6	90
"	Dalkeith	6 ft	C	3.8	40.0	91
"	Woolmet	Ell	B	3.1	36.8	89

The pressure required to make these compacts was about 6 ton/sq.inch, although for the higher coke types somewhat lower pressures were often adequate.

The plant results therefore show that the hot char briquetting process is applicable to a wide range of low rank coals, and thus confirm and extend the earlier laboratory findings.

3.3.2. The Carbonisation Conditions

The plant investigation of the effect of carbonisation variables on briquetting has been rather more restricted because of plant limitations than that in the laboratory. An investigation using Dexter coal, C.R.C. No. 902, has, however, been made of the variation of briquette quality with temperature (in the range 375°C to 450°C), and residence time (15 min to 45 min). In order to achieve the longer residence times it was necessary to dilute the fluidising air with nitrogen, although on a larger plant a deeper bed could be used.

The results of combined shatter and abrasion tests carried out on briquettes made using a constant pressure of 7 ton/sq. inch for the above range of carboniser variables are given in Fig. 8. As with the laboratory results it may be seen that the strongest briquettes are made in the range 400°C - 450°C, and that quality diminishes with increasing residence time.

As with the laboratory briquettes the volatile matter content for optimum strength is higher than the 23% at which the char is completely smokeless.

3.3.3. The Compaction Conditions

In the laboratory it was shown that any substantial reduction of temperature between carboniser and press produces a weaker briquette.

Tests were carried out on the plant by removing heating and lagging from the short feed line connecting carboniser and press. The briquetting temperature as indicated by thermocouples in the char stream are given in Table 4, together with the shatter and abrasion indices of the briquettes produced.

TABLE 4

Variation of Briquette Strength* with Briquetting Temperature. (Plant Results)

Carbonisation Temperature	425°C
Briquetting Temperature	Briquette Strength*
425°C	93
400°C	87
350°C	84
285°C	83

* Results quoted are the combined plant shatter (+ 1") and abrasion (+ $\frac{1}{8}$") test results.

+ All briquettes were prepared at a pressure of 7 ton/sq. inch.

Over the limited range of temperature drop investigated in this way there was a reduction in quality with increasing temperature drop; this confirmed the laboratory results. It is preferable to permit no fall in char temperature between the reactor and the press: indeed there may be a case for using a rising temperature gradient.

With respect to other briquetting variables it has been found on the plant that density increases with pressure, but that the rate of increase falls at higher pressure, as would be expected. This is true also of briquette strength, but on extrusion presses another effect is important. At high pressures the separation between successive briquettes becomes poor, and in some cases continuous lengths of undivided briquette emerge from the nozzle. For briquette appearance it would thus appear that pressures which are too high can be a positive disadvantage and this seems to be particularly the case with the more highly caking coals. However, wherever this phenomenon has been encountered it has been found possible to make strong briquettes at pressures below those which bring about severe sticking.

3.3.4. Quenching Conditions

In bulk production of char briquettes it is necessary to introduce a cooling stage to prevent spontaneous combustion of the product and it has already been pointed out that, in the assessments so far of process variables, the product has been dry quenched in sealed drums. Cooling in this way takes between 12 hours and 2 days, depending on whether 90 lb or 250 lb drums are used.

Quite early in these investigations wet quenching by immersion in water was considered as an alternative. By this means briquettes can be quenched to a safe temperature (i.e. about 50°C) in 20 min., but such cooling produces internal cracking and gives substantially lower shatter indices than those obtained for a dry cooled product. This is particularly true for briquettes produced at 425°C, and for the more highly caking coals.

Experiments on cooling briquettes in fluid beds of cold sand and in dry ice quickly demonstrated that the rate of cooling rather than the nature of the coolant was responsible for the cracking.

When a briquette emerging from a press at about 400°C is plunged directly into cold water it suffers a large thermal shock. The shock can be reduced by cooling the briquettes more slowly, either in an inert atmosphere or by spraying lightly with water, prior to complete immersion. That such a two-stage cooling procedure reduces internal cracking is illustrated in Fig. 9, where sections of briquettee dry cooled in sealed tins for 10 and 20 min. before immersion in water are compared with briquettes which were immediately immersed.

Plant investigations have shown that it is desirable to reduce the average temperature gradually to about 150°D before immersion in water. The first cooling stage can be performed by cooling on a conveyor in a steam atmosphere for 30 min., or by a shorter period, (15 min.) of spray quenohing (see Fig. 10), followed by 8 min. immersion in water. These two-stage treatments gave briquettes closely comparable in strength with those cooled in sealed drums. For commercial exploitation, steam cooling, followed by water immersion, is preferred.

3.3.5. Smoke Emission & Fuel Performance

With the greater supply of product from the plants it was possible to carry out open, i.e. stool-bottom, grate tests[10] and coke grate tests[11] for radiation and visible smoke. Smoke emission may be measured optically using a photo-electric cell to measure the obscuration of a light beam traversing the flue or the smoke may be collected in an electrostatic precipitator and weighed. The second method is likely to be accepted as a British Standard method but for our purpose the convenience of the optical method outweighed the rather better accuracy of the gravimetric method.

Optical smoke indices are given in Table 5. Values obtained from other "naturally smokeless" coals are included for comparison. The parent coal, in this case Dexter C.R.C. No. 902, gave an index of 93.

It can be seen that smoke emission decreases rapidly with increasing carbonisation temperature and decreasing volatile matter content until the product becomes virtually smokeless at 23% volatile matter content. Further, the range of smoke emission of the "naturally smokeless" fuels given in Table 5, is wide enough to give considerable latitude in process conditions for the production of a strong briquette.

TABLE 5

Smoke Emission Indices for briquettes burned in stool-bottom and coke grate tests

a) Smoke index of briquettes made from Dexter char; 30 min. residence time in carboniser.

Carbonisation temperature °C of the briquettes .	375°C	400°C	410°C	425°C	450°C
Volatile matter content d.a.f. of the briquettes	32.3	27.9	26.0	23.4	21.0
Smoke emission index in stool-bottom tests	23	10	4	2	<1
Smoke emission index in coke grate tests	18	13	5	2	<1

b) Sample smoke indices of other coals for comparison

(i) Stool-bottom grate

			Index
International coal	16.5% V.M. d.m.m.f.	(3" x 2")	35
Deep Navigation coal	14.0% V.M. d.m.m.f.	(3" x 2")	7
Penrikyber coal	12.7% V.M. d.m.m.f.	(3" x 2")	3
Commercial Low Temperature Coke		(+ $\frac{3}{4}$")	3

(ii) Coke Grate

International coal	16.5% V.M. d.m.m.f.	($2\frac{1}{4}$" x $1\frac{1}{4}$")	33
Deep Navigation coal	14.0% V.M. d.m.m.f.	($2\frac{1}{4}$" x $1\frac{1}{4}$")	8
Penrikyber coal	12.7% V.M. d.m.m.f.	($2\frac{1}{4}$" x $1\frac{1}{4}$")	4
Commercial Low Temperature Coke		(+ $\frac{3}{4}$")	2

The critical air blast test[12] showed the fuel to be "reactive" in that the required air blast was less than the minimum flowused in this test (0.008 cu. ft. air/min). The general performance of the briquettes in stool-bottom grate tests is illustrated in Table 6; it can be seen that, apart from smoke, the performance of the briquetted fuel equals that of the parent coal.

TABLE 6

Performance of Dexter coal and Dexter char briquettes in stool-bottom grate tests*

Fuel Tested	Dexter $2\frac{1}{4}$" x $1\frac{1}{4}$" coal	Dexter Char Briquettes (425°C)
Time to reach 6,000 B.t.u./h after ignition (min)	28	29
Peak radiation after ignition B.t.u./h	10,410	8,060
" " " 1st refuel "	10,530	9,940
" " " 2nd " "	9,140	9,990
" " " 3rd " "	8,550	9,130
Gross radiation (2000-2000 B.t.u./h) B.t.u.	67,380	69,070
Average radiation per hour "	6,670	6,470
" " " pound " of fuel burned	2,900	3,020

* In the stool-bottom test a fire is lit using 9 lb. of coal and recharged three times using 5 lb. of coal per refuel.

4. DISCUSSION

So far we have reviewed some of the main process variables involved in briquetting hot char in an extrusion press as revealed by laboratory and small pilot plant investigation. We have shown that a strong briquette can be made and that there is a fair range of conditions under which the briquette is also smokeless, but we have not considered some of the variables which are of great importance to the commercial success of the process.

First is the ability of the carbonising and briquetting systems to operate continuously over reasonable periods without shutdown. The carbonising system is particularly prone to troubles associated with agglomeration in the bed and the extrusion press is susceptible to high rates of die wear. In order to get some measure of these likely difficulties a 500 hr. run on an 18 in. dia. carboniser/2" dia. extrusion press rig was attempted. Only minor difficulties were encountered in the carboniser and die wear was found to be much less troublesome than had been expected.

For commercial use it is necessary to operate the extrusion press at much higher speeds than is possible on small pilot plant where the limit was about 40 strokes per minute. The limit was set primarily by the capacity of the carboniser but was also influenced by the transient shock waves which are characteristic of hydraulic presses operating at high speed. Recent experience on a variable speed mechanical press, Fig. 11, has shown that good briquettes can be made at speeds of 80 strokes per minute, and that higher speeds may well be possible. Attempts have also been made to briquette the char on roll presses, these have been successful but demand very close control of carboniser conditions.

Briquette shape is important commercially and some of the variants possible on an extrusion press are illustrated in Fig. 12. In order to obtain optimum fuel performance on an open fire, briquette weight should not exceed 100 grms.

Tonnage quantities of briquettes have been made for market and transport trials, and Fig. 13 gives some idea of the appearance of a wagonload of dry quenched briquetted after a transport test.

The fuel has been shown to be an acceptable premium grade smokeless fuel for the domestic market. It is smokeless at volatile contents between 23 and 26% and is made without unpleasant and expensive binder. Preparations for commercial development are already in an advanced stage. It remains to exploit the virtues of this process in the manufacture of closed stove and metallurgical fuel, and to extend the range of coals which can be processed in this way.

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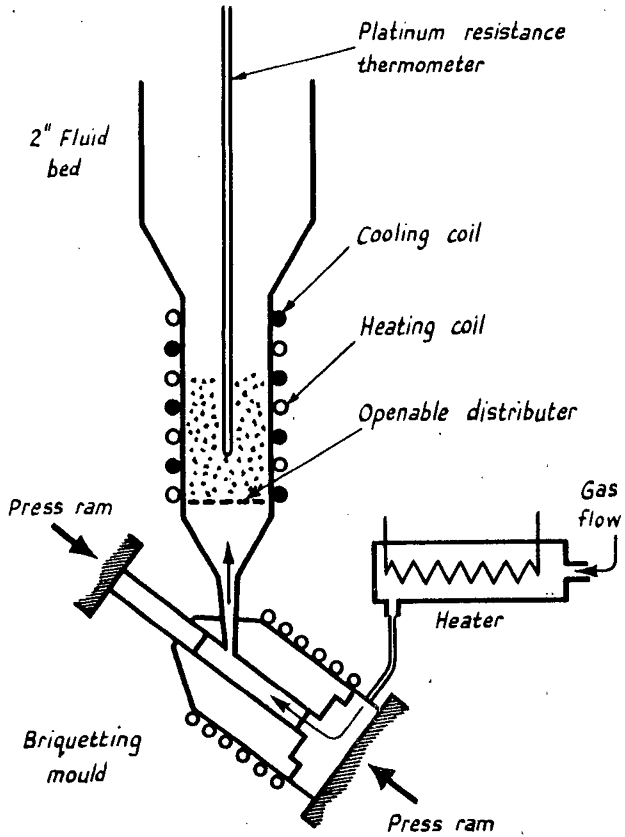

FIG. 1. LABORATORY BRIQUETTING APPARATUS

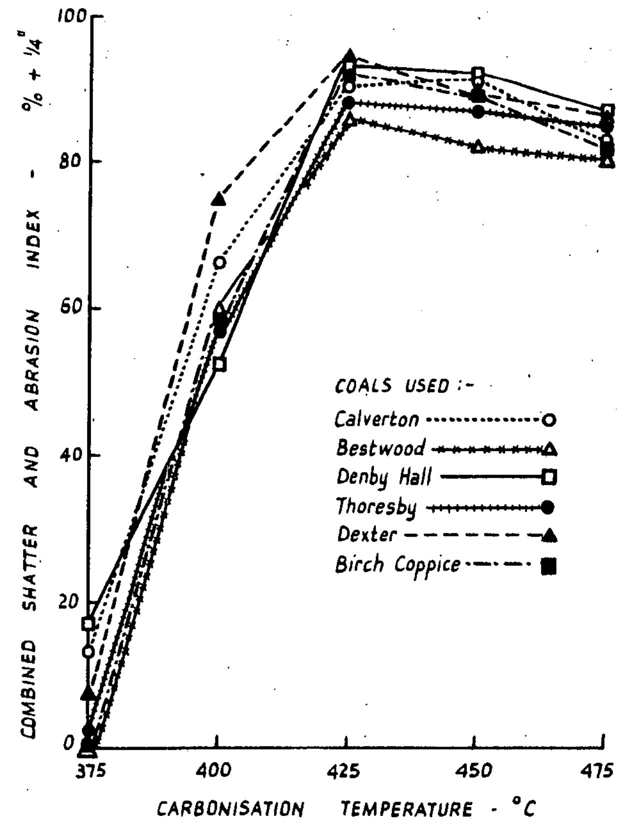

FIG. 2. BRIQUETTING PERFORMANCE OF SIX LOW RANK COALS.

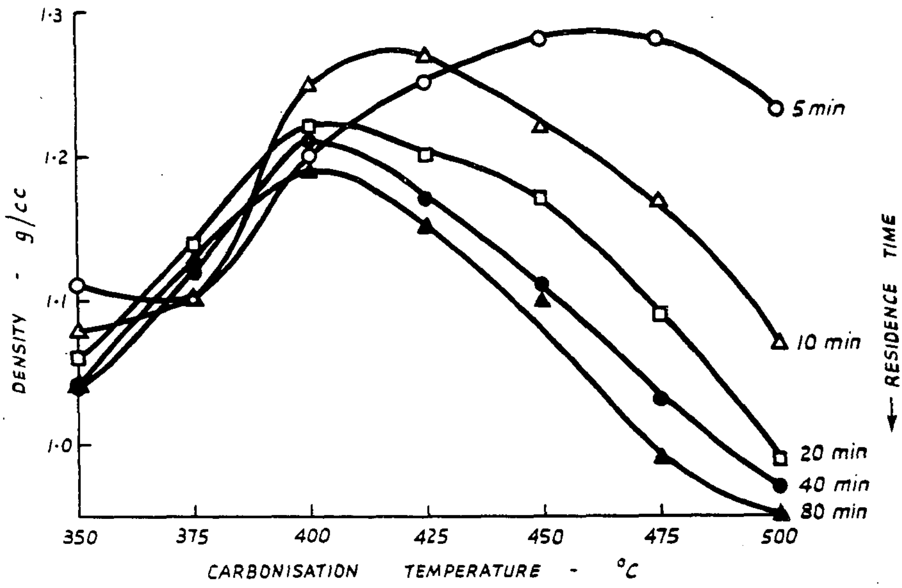

FIG. 3. VARIATION OF DENSITY WITH TEMPERATURE AND TIME.

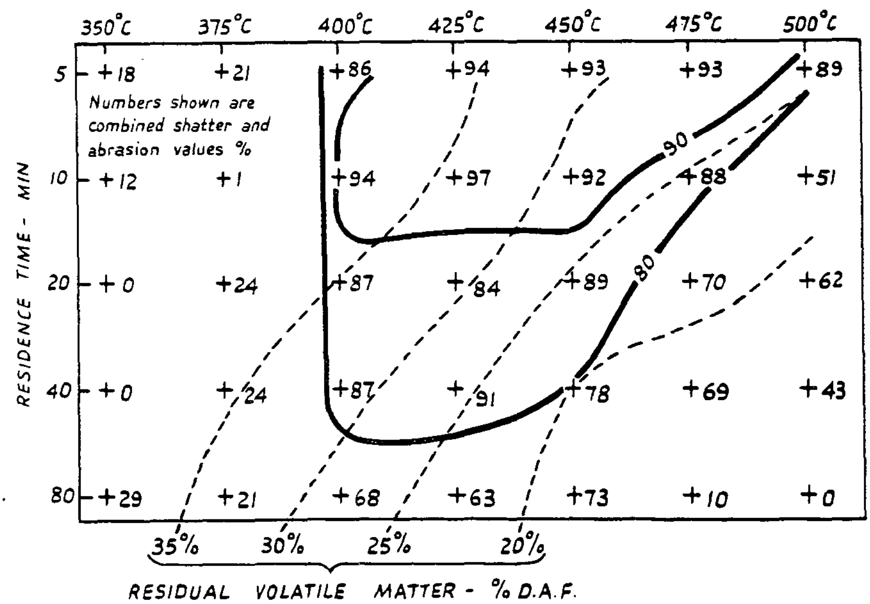

FIG. 4. VARIATION OF STRENGTH WITH TEMPERATURE AND RESIDENCE TIME. (LABORATORY RESULTS)

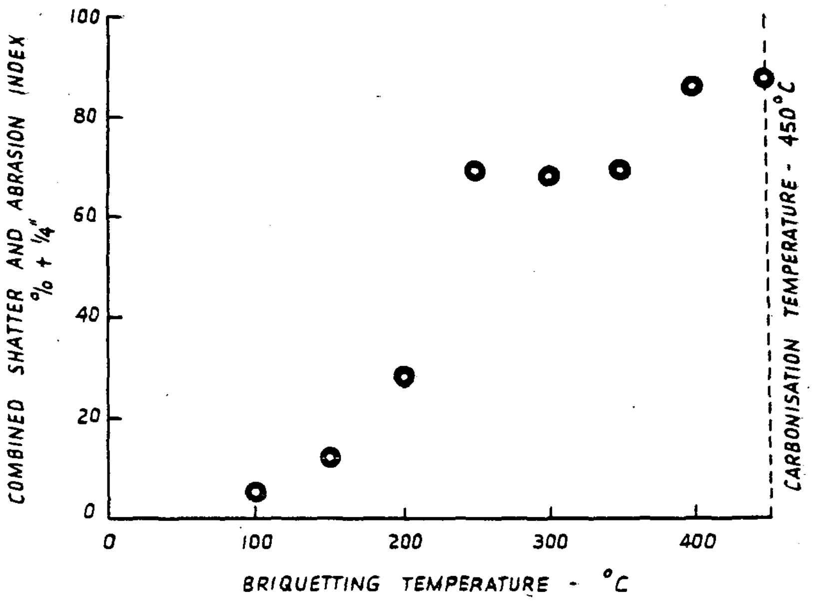

FIG. 5 EFFECT OF BRIQUETTING TEMPERATURE ON STRENGTH.

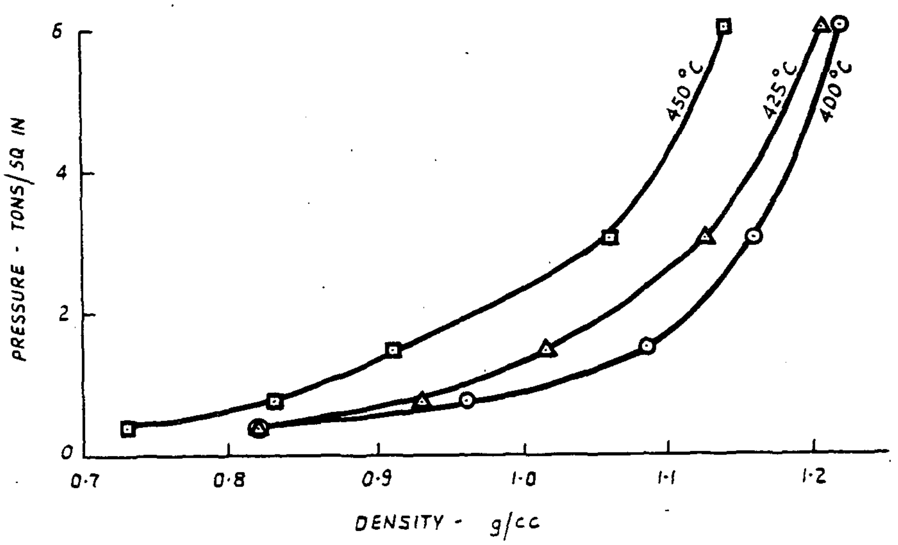

FIG. 6 VARIATION OF COMPACTION WITH PRESSURE.

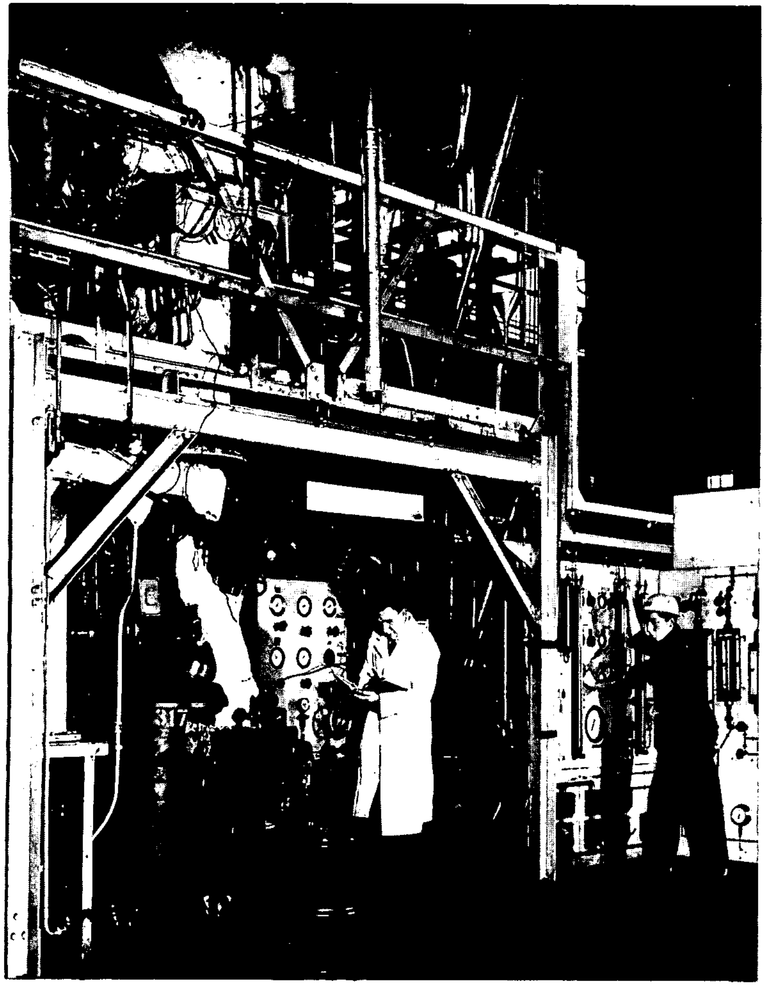

FIG. 7. 100 lb/h PLANT

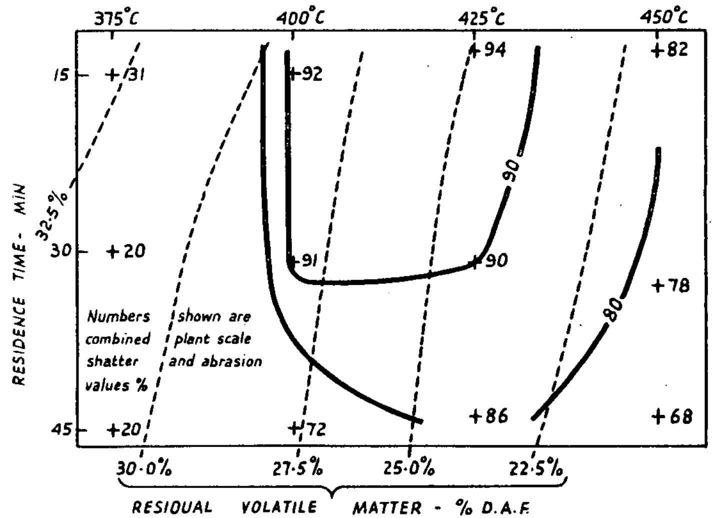

FIG. 8. VARIATION OF STRENGTH WITH TEMPERATURE AND RESIDENCE TIME. (PLANT RESULTS)

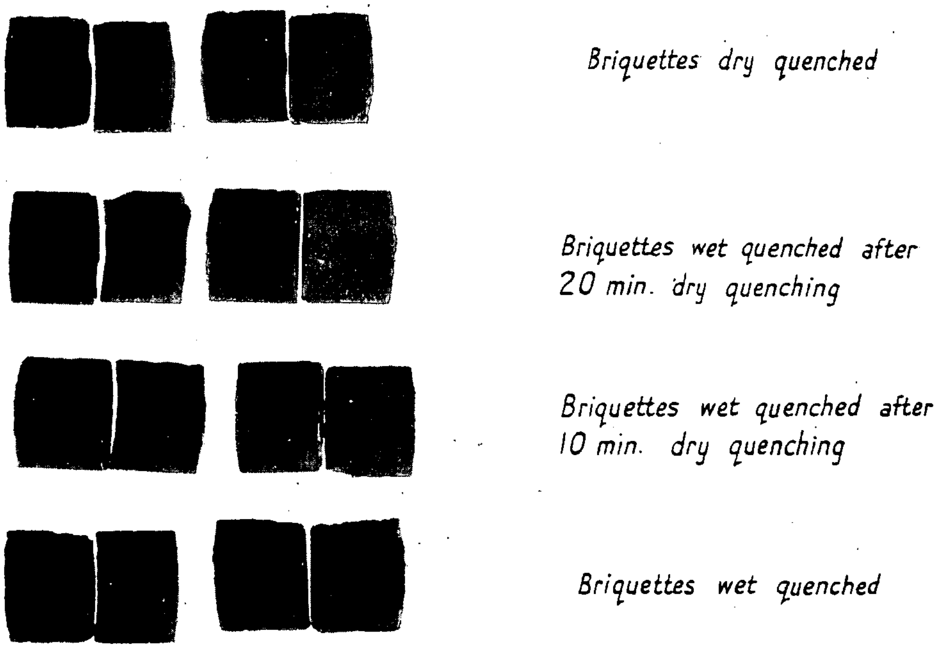

FIG. 9. SECTIONS OF BRIQUETTES AFTER QUENCHING

FIG. 10. TWO-STAGE QUENCHING FACILITIES ON A SMALL PILOT PLANT

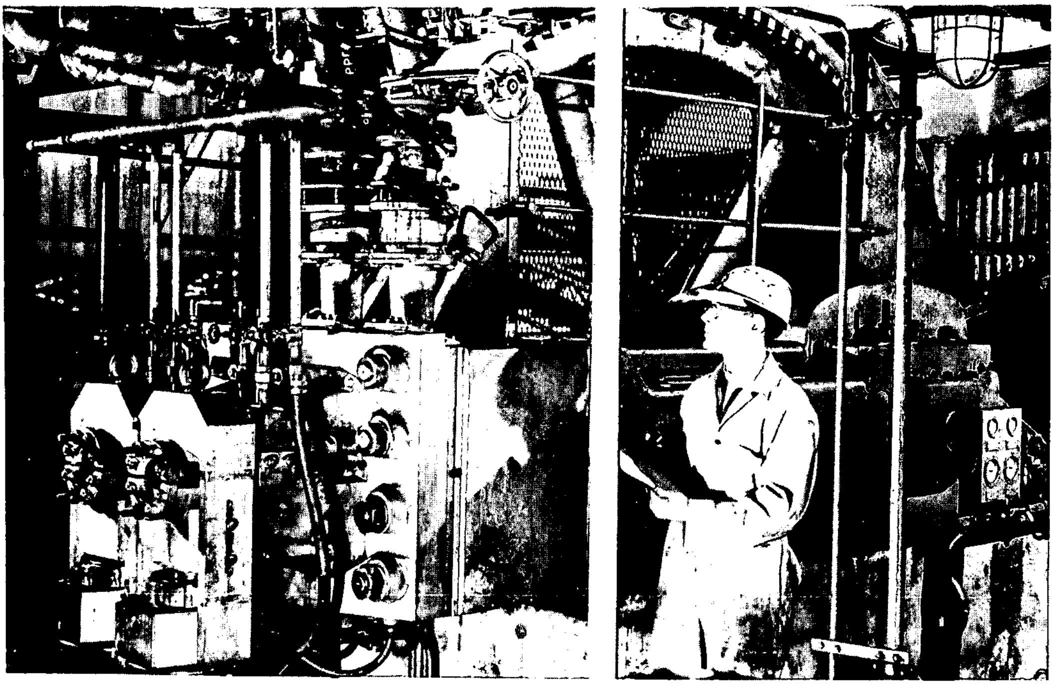

FIG. 11. MECHANICAL EXTRUSION PRESS

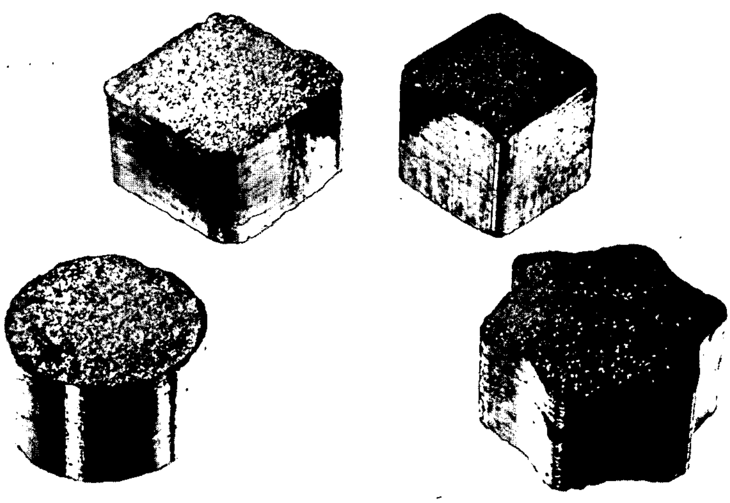

FIG. 12. EXTRUSION BRIQUETTES OF VARIOUS CROSS - SECTION

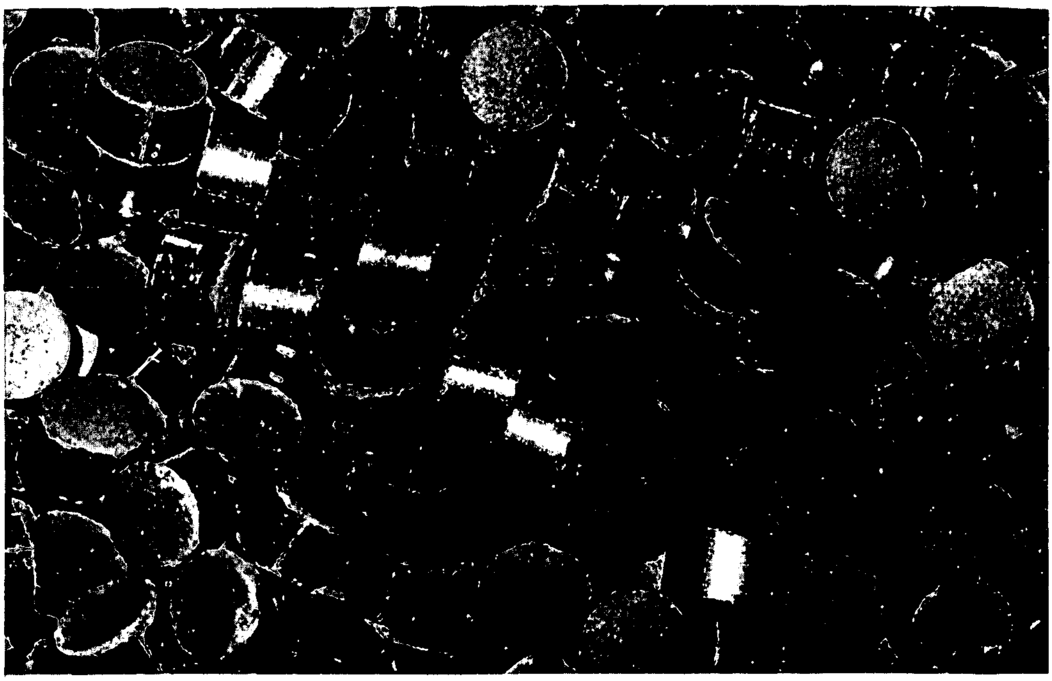

FIG. 13. BRIQUETTE APPEARANCE AFTER 200 MILES RAIL TRANSPORT