Some aspects of preparation of Coal for Coking (II)

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THE plans for India's industrial expansion envisage manifold increase in all branches of engineering industries with a concommittant increase in the production and consumption of all quality of coals.

Although India has fairly large reserves of inferior grades of coals, her resources of coking coals, including the washable reserves, are by no means plentiful. To meet the demand of increasing production of steel for the successive Five Year Plans, the consumption of coking coal will be stepped up many times. This will result in even a quicker rate of depletion of the dwindling reserves of coking coals. There can, therefore, be no difference of opinion about the need for restricting the use of metallurgical coals for coking purpose alone and for the adoption of suitable means for the beneficiation of the high ash coals.

The installation of the coal washing plants, both in the private as well as public sectors, and the projects of erecting more washeries are concrete steps towards this objective, but much still remains to be done, and it has to be admitted that the magnitude of the problem has not yet been fully realised.

Elaborate techniques in the preparation of the coking coal mixture by selective crushing, blending, addition of oil, etc. are becoming more and more a common feature in all countries where the shortage of coking coal is being felt more acutely. Serious attention is now being given to such improved methods of coal preparation even in countries like the United States[1] and U.S.S.R[2]. in spite of the high quality of the bulk of their coking coal reserves. It has been shown by statistical data collected over years that considerable improvement can be effected in the strength of the coke by judicious preparation of the coking mixture.

This improvement in the coke quality contributes not only to better performance of the blast furnace but results in an increase in the yield of usable coke, both these factors leading ultimately to an overall economy in the use of coke in the blast frunaces.

Since about three-fourth of the fuel consumed in the manufacture of iron and steel is in the form of coke and 80 per cent of the total hard coke is produced in the steel works for use in their own blast furnaces, the iron and steel industry in India has a special responsibility in this regard.

In spite of great advancement that has been made in the coking industries and research organisation in some countries abroad, the fundamental principles involved in blending of coal are not yet fully understood.

It is however clear that the inherent heterogeneity in coals which persists even after washing, demands a thorough admixture of their different petrographic and associated mineral constituents before they are subjected to the process of carbonisation with the objective of producing hard and strong coke. The situation becomes all the more aggravated when a number of different coals are used for coking and especially when substandard grades of coals have to be utilized.

Investigation carried out in the Central Fuel Research Institute and the C.B.C.R. Sub-Committee, Jamshedpur have shown that the Indian coals are in some respects basically different from coals of other countries and the approach to the technique of coal preparation in India has, therefore, to be different from that developed abroad. In this paper, the results of such studies have been discussed and suggestions offered for adopting specific systems of coal preparation suitable for Indian coals showing at the same time the extent of economy which may accrue in the consumption of coal from implementation of the findings of the Research Institutions.

Heterogeneity of coal

Coal is a heterogeneous mixture of several discrete petrographic constituents commonly known as durain, vitrain, clarain and fusain as well as a number of inorganic minerals. They all possess characteristic chemical and physical properties, and the relative proportions of these constituents often widely vary even for coals of the same rank from the same seam. The "dulls" or the durainous constituents of coals are the hardest and show the least caking, swelling and fluid properties. The fusainous part is the softest and is absolutely inert. Besides this, a coal always has varying proportions of comparatively hard extraneous and inherent inert matter

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[1] Brisse, A. H. and Harris, H.E.[1] "Some Basic Principles of Pulverization and Preparation of Coking Coal Blends", Blast Furnace and Steel Plant, Vol. 45, 1957 pp. 301–307.

[2] Tumakin, L. A. and Koksikihim "Crushing of Coals for Coking", Vol. No. 8, 1957 pp. 7–9. (Fuel Abstract Jan, 1958 pp. 143).

forming ash on combustion. The more common petrographic constituents of coals are shown in the Fig. 1 and 2.

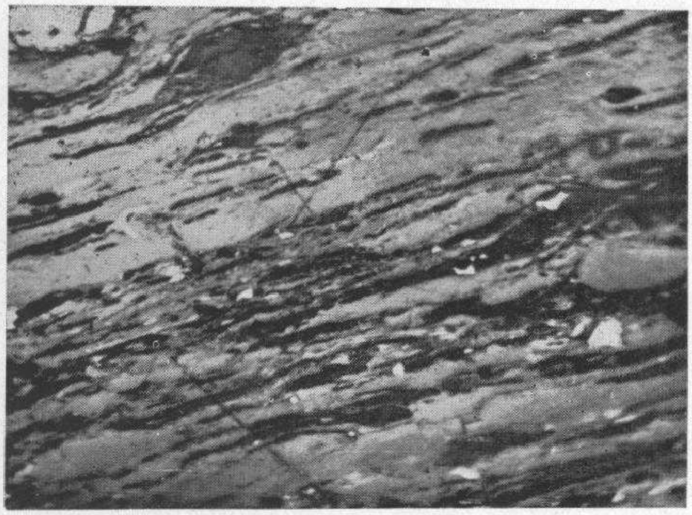


Fig. 1.
Photomicrograph showing dark grey, nearly black elongated bodies of micro-spores (exinite) in a ground mass of grey vitrinite. Small bodies of white micrinite showing high reflectance are also seen. Vitrinite and exinite meet during coking process and provide the "fluid" or the cementing medium necessary for the production of coke. X 375, oil immersion.

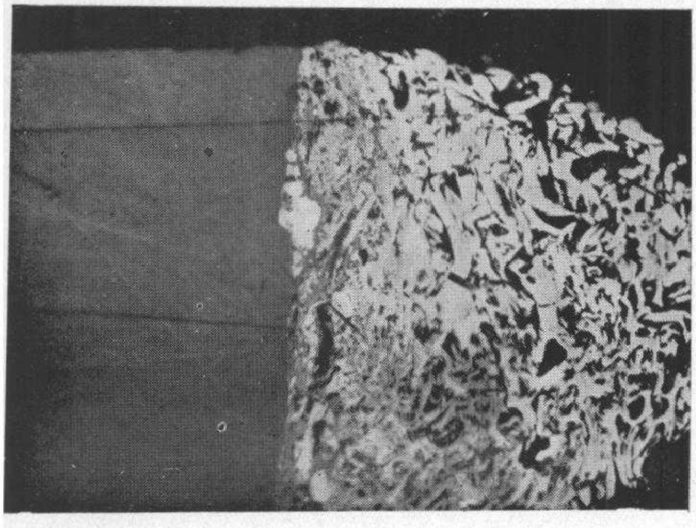


Fig. 2.
Photomicrograph showing gradual transition from vitrinite (grey) through semi-fusinite to fusinite characterised by increased reflective power and more marked cell structure. Fusinite, semi-fusinite and micrinite remain inert to coking process but if dispersed properly through the coking charge they act as ballast and impart strength to the coke as stone-chips do in cement concrete. X 375, oil immersion.

The separation of the different petrographic constituents of coal by hand picking is impossible. When floated in liquids of increasing specific gravities, a rough gradation of the coal is possible into purer vitrain and clarain of lower ash and into higher ash fractions containing gradually increasing proportions of durains, fusains and shaly impurities.

TABLE I

Properties of different specific gravity fractions of a coal

Sp. Gr.	Ash %	C. I.	(Gieseler Tests) Max. fluidity dial div./min.
1·30	6·2	24	6,400
1·30–1·35	11·9	23	2,000
1·35–1·40	16·9	20	706
1.40–1·50	23·5	18	118
1·50–1·60	30·3	14	3
1·60–1·70	38·9	12	1
1·10–1·80	46·7	9	0·7
1·80	66·7	7	No fusion

Table I shows the caking and fluid properties of the washed fractions of different coals as determined by B.S. caking index, and Gieseler plastometer tests. It may be seen that there is a progressive lowering in the caking and fluid properties with an increase in the percentage of ash, i.e. decrease in the contents of purer "brights" of the coal. There is marked difference in the properties of the lightest and the heaviest materials.

The grindability tests (Hardgrove Index) of different specific gravity fractions of coals from various sources have shown[3] that the index is generally the highest at the lowest specific gravity fraction (i.e. for the "bright") and gradually decreases in the higher gravity fractions.

Need of fine crushing

When subjected to a process of crushing in conventional mills as in normal coke oven operation, the "brights" of the coal (vitrains and clarains) which are more easily breakable get crushed to a greater degree of fineness than the durainous "dulls" and associated impurities which are the hardest. This will be evident from Table II which shows the distribution of the various petrographic constituents in the different screened fractions of a crushed coal. The caking, swelling and plastic properties and the grindability of these fractions as given in Table II are found to be progressively higher for the finer fractions which contain larger proportions of the coal "brights". Figs. 3 and 4 show the nature of distribution of the different petrographic constituents of coal in the coarsest and finest fractions.

[3] Ghosal, A. and et al "Grindability of Indian Coals". The Institute of Fuel, Vol. XXXI No. 205, Feb., 1958 p 50–55.

TABLE II

Properties of screened fractions of a crushed coal

Fraction	Petrographic constitution: Brights	Petrographic constitution: Dulls	Ash %	Caking index B.S.	Gieseler test max. fluidity	Sheffield coking test gross expan. %	Grindability hard-grove index
½"–¼"	74·1	25·9	18·6	17	280	6·7	60
¼"–⅛"	76·6	23·4	16·5	19	1,000	14·5	61
⅛"–$\frac{1}{16}$"	78·9	21·1	13·9	21	1,640	22·4	68
$\frac{1}{16}$"–36 mesh	80·6	19·4	12·2	22	2,540	32·8	78

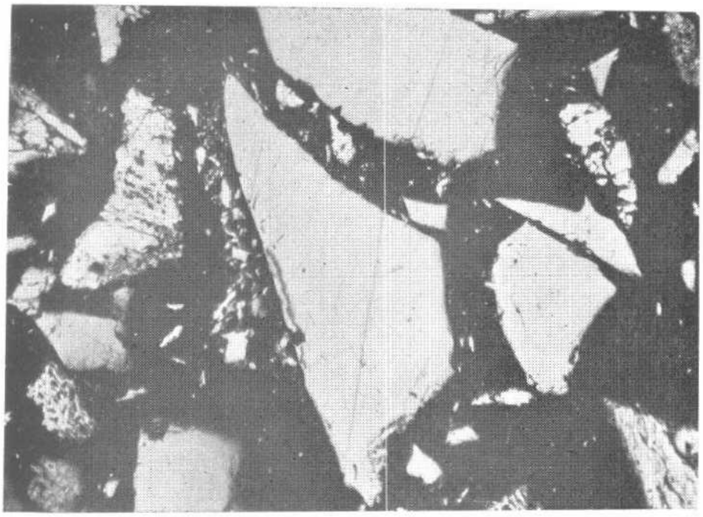


Fig. 3.

Photomicrograph showing concentration of vitrinite (grey) over inertinite (white bodies having higher reflectance consisting of fusinite, semi-fusinite, micrinite, etc.) in the finer size fraction (minus 36 mesh B.S.) of a crushed and screened coal. It is because of the concentration of vitrinite (brights) that the caking, swelling and plastic properties are more marked in the finer screen fractions. X 200, oil immersion.

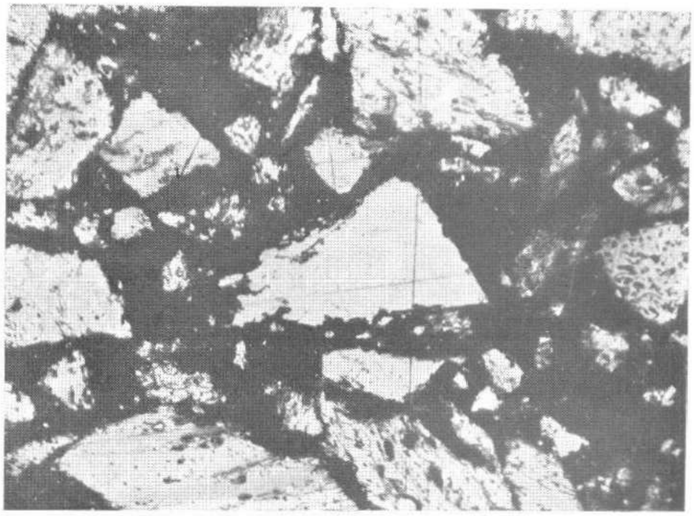


Fig. 4.

Photomicrograph showing concentration of inertinite over vitrinite in the coarser size (3"–2") of the same coal as stated in Fig. 3. The coke-making properties are much less marked in such a case. X 200, oil immersion.

Thorough dispersal of the mineral matter and of the poorer caking, less fluid, dull constituents of the coal throughout the entire mass of coal used for coking is essential for the production of hard and strong coke. Due to the concentration of the harder and comparatively inert constituents in the larger sizes, carbonisation of coarsely crushed coals often results in coke of an uneven texture and the comparatively large pieces of durain and shales remain in an unfused state forming nuclei of fissures and fractures which weaken the mechanical strength of the cokes.

On the other hand, too fine grinding of the coal "brights" is also undesirable. The inerts of the coal should not also remain in the coking mixture as fine dust which enormously increases the surface area in the coal charge causing undue absorption of the binding material of the coal. Total fine grinding also lowers the bulk density and produces the undesirable "bug dust".

The gradual improvement in all the physical properties of coke by finer crushing of a typical Jharia coking coal will be evident from Fig. 5.

When a mixture of different coals is used for coking, the lack of homogeneity in the crushed coal becomes aggravated due to the different hardness of the coal constituents. Studies in this Institute have shown[3] that the coals whose volatile matter lies between 20 and 30 per cent (d.m.f.) are the easiest to grind and coals of volatile matter 35 per cent and above are the most difficult to grind. This is also evident from the screen analyses of coals A, B and C crushed in a hammer mill as shown in Fig. 6.

TABLE III

Screen analysis of a coke oven coal mixture

Year	Range of fraction % by wt.: Over ½"	Between ½"–¼"	Between ¼"–⅛"	Below ⅛"
1.	1·9– 3·5	9·6–26·9	14·5–21·5	44·2–72·3
2.	2·3–12·1	9·6–19·8	10·6–27·6	54·7–72·2
3.	0·3– 4·3	9·3–14·1	17–19·1	65·4–72·8

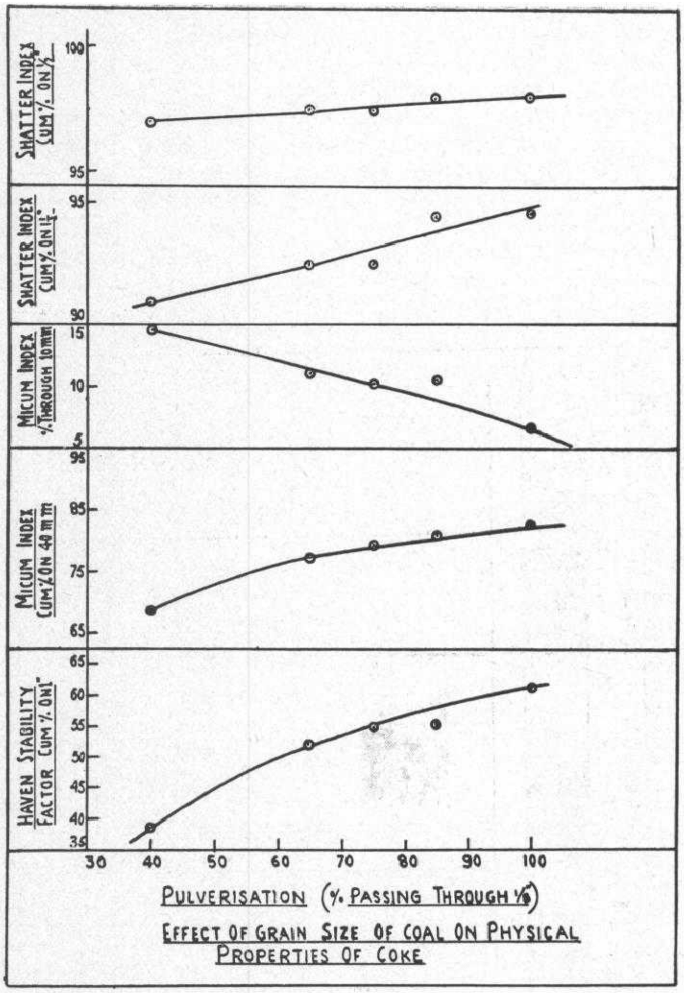


Fig. 5.

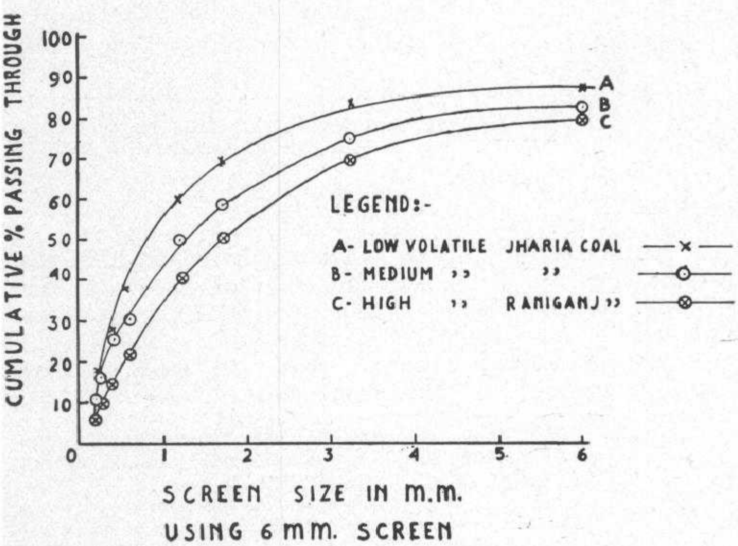


Fig. 6.

Table III shows the range of size distribution of the coking coal mixtures of a steelworks for three years pertaining to the periods when 100 per cent of unwashed coals varying in volatile matter from 22 to 29 per cent procured from 20 to 25 different sources was being used.

It may be seen that mainly due to the difference in the crushing characteristics of the different coals, the desired fineness of about 80 per cent through $\frac{1}{8}$ in. could not be maintained during these periods. The percentage of material above $\frac{1}{4}''$ in the crushed coal roughly ranged between 14 and 20 and was often higher. The fraction on $\frac{1}{2}''$ was sometimes as high as 12 per cent with about 30 per cent ash. It should be clearly understood that differential breakage leads not only to seggregation of the petrographic constituents but also of the ash forming constituents which generally tend to concentrate in the harder durainous fractions of the coal.

The adverse effect which such coarse crushing of coals may produce on the coke quality and the improvement that may be expected by finer crushing will again be apparent from Figs. 7 and 8 which show the concentration of the impurities of the coals in the coarser size and from Figs. 9 and 9 (*a*) which show the quality of the cokes. While there are shaly inclusions inducing zones of fractures and fissures in the coke from the coarsely crushed coals, they are totally absent in the coke from the finely crushed coals and the coke shows a more uniform and finer structure.

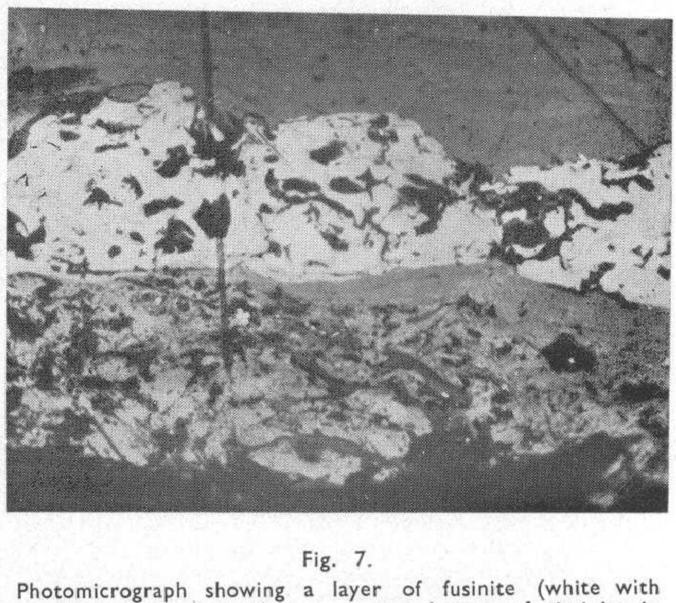


Fig. 7.

Photomicrograph showing a layer of fusinite (white with cellular structure) in the grey ground mass of vitrinite in a coal coarsely crushed. The fusinite which will remain in an unfused state during coking will give rise to a zone of weakness causing fissuring and fracturing and this leads to the weakening of the mechanical strength of coke. X 200, oil immersion.

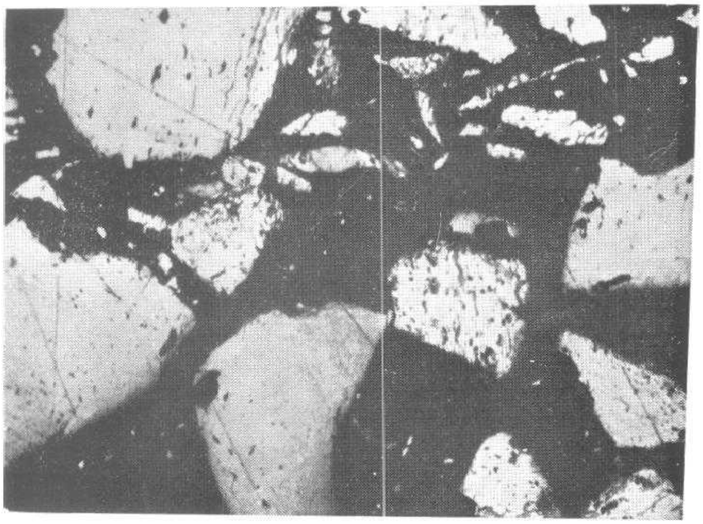


Fig. 8.

Photomicrograph showing the distribution of the fusible (grey vitrinite, etc.) and the inert constituents (highly reflecting constituents like fusinite, micrinite, etc.) in a coal finely crushed. It may be noted that the inertinites, instead of occurring as discrete layers, are dispersed in the charge. This is particularly helpful from the standpoint of producing strong coke. X 200, oil immersion.

Selective crushing

A process of coal preparation, known as the Burstlein-Longway system[4], has recently been developed in France principally with the objective of utilising increased proportion of deficiently coking coals. By controlled and selective crushing, the most fusible constituents are removed by screening at an early stage, the harder constituents are then subjected to more intensive grinding to reduce their size. The petrographic composition of the charging coal can be maintained constant even while using different coals by drawing off and using for other purposes the excess of either the softer or harder constituents.

In the simplest type of plant where the same kind of coals is used, the incoming coal (already broken in mixing and handling) passes through a trommel mixer and then over electrically heated screens varying in mesh according to the type of the coal treated (generally 2 to 3 mm.). The undersize consisting of the fusain and the fusible "brights" directly passes through and constitutes the blend to be coked. The oversize consisting of the durain, shale and unbroken coal goes to a breaker where it undergoes progressive reduction in size and is then recycled to the mixer. The breaker employed is much milder in action compared to the conventional hammer mill or disintegrator. This fact and screening before the breaker give a final product containing much less fines than a normal coke oven charge, bringing each constituent of the incoming coal to the optimum size and is distributing them roughly equally in all the size fractions which is essential for the production of a strong and uniform coke. The plant differs in complexity to suit different types of coals and it is often necessary to employ more than one circuit and double deck screens. Plants of this design capable of handling 1,500–3,000 tons of coal a day are known to be in operation in France, Germany and North Africa.

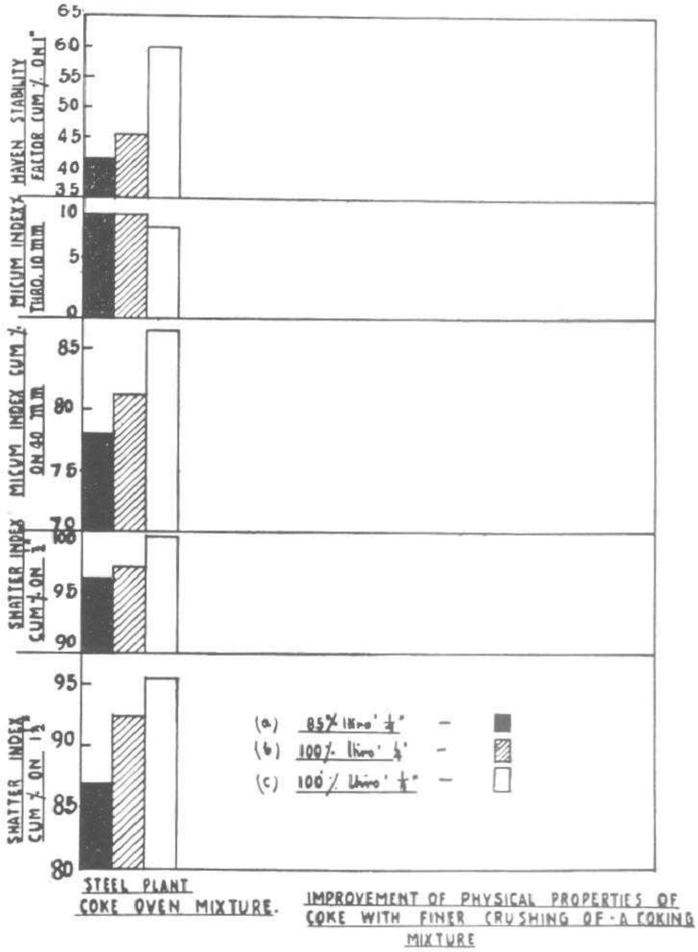


Fig. 9.

While marked improvement can be effected in the coke quality by finer crushing of most Indian coals, investigation at the Central Fuel Research Institute has shown[5, 6] that superior quality coke is not necessarily obtained from all coals crushed under strictly controlled conditions.

4 Ghosal A. and et al "The Petrographic Preparation of Coals for Coking" Part I and II. Coke and Gas, July and Aug., 1955, pp. 246–251 and pp. 288–292.

5 Das Gupta, N. N. and et al "Selective Crushing of Coal"—presented in the Coal Carbonisation Symposium held in C.F.R.I., Jealgora, India in March, 1957 (in press).

6 Ghosh, S.R. and et al "Studies on the Selective Preparation of Indian Coals for Carbonisation" presented in the Coal Carbonisation Symposium held in C.F.R.I., Jealgora, India in March, 1957 (in press).

Table IV

Properties of coke from coals crushed under different condition.

Coal sample No.		A High volatile weakly coking coal		B Low volatile good coking coal	
		1	2	1	2
Physical properties of coke					
Shatter	% on 1½″	79·3	81·2	92·6	92·5
Index	% on ½″	97·0	95·6	98·0	97·4
Micum	% on 40 mm	60·6	49·9	82·6	77·1
Index	% on 10 mm	11·6	15·6	18·3	12·0
Haven stability factor	% on 1″	29·4	15·8	61·5	52·0

FLOW SHEET A

(Straight or normal crushing)
Original Coal. 3″–0″ size
↓ Crushed in Pulveriser (about 70 through ⅛″) and Screened on ⅛″ (or ¼″ mesh.)

+ ⅛″ (or + ¼″) recrushed fine in Hammac using 1/16″ screen. — ⅛″ (or — ¼″)

↓
SAMPLE—(1)

FLOW SHEET B

(Controlled Crushing)
Original Coal. 3″–0″ size

Mild Crushing (Hand)
↓ passed through 2″
Mild Crushing
↓ passed through 1½″
Mild Crushing
↓ passed through 1″
Mild Crushing
↓ passed through ½″
Mild Crushing
↓
Screened on ⅛″ (or ¼″) mesh
↓

— ⅛″ (or — ¼″) + ⅛″ (or + ¼″) Crushed coarse using a coffee grinder to pass through ⅛″ (or ¼″)

↓
SAMPLE—(2)

Table IV gives the quality of coke obtained from two coals crushed under two distinct sets of conditions. In one series of tests the coals were manually crushed to reduce the size in stages from an initial of 50 mm. to minus 3 mm. and in the other series it was more drastically crushed, in a hammer mill in one operation down to the same size limit. The manner of crushing is shown in flow sheets "A" and "B".

For both the weakly coking high volatile and good coking low volatile coals, the cokes obtained from the coals crushed in the hammer mill and containing higher percentage of fines corresponding to curves of irregular shape as shown in Figs. 10 and 11 were distinctly superior to the coke obtained from the coals showing a closer size grading and containing less of fine as obtained from crushing in stages. This shows that both the coals needed

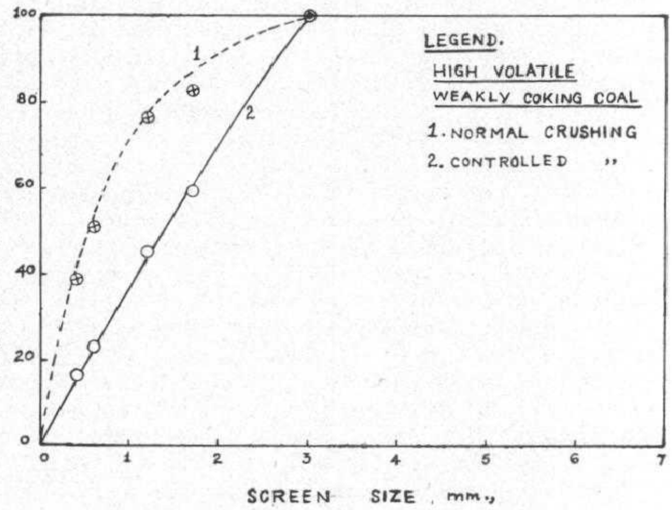


Fig. 10.
Effect of nature of crushing on screen analysis.

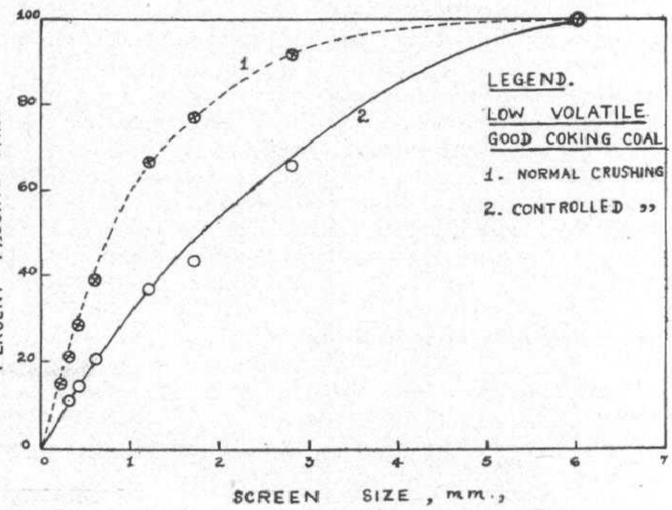


Fig. 11.
Effect of nature of crushing on screen analysis.

finer crushing to pass through a maximum size limit irrespective of the manner in which it was achieved. It is, however, admitted by all as has been already stated earlier that the "brights" of the coals should not be ground too fine. This can be achieved by the use of an impact type mill in conjunction with a screen of appropriate size as discussed later in the paper.

Requisites for good blending

Blending of coals for carbonisation aims at delivering the carbonising mixture to the plant in a uniform state in every respect. It is not often recognised that this means much more than mere mixing of two or more components. Since it is not possible to have guaranteed supply of coals from the same sources in predetermined sequence, arrangements have to be made for separate storage of different coals for their subsequent mixing in the desired proportion. This is essential for large plants consuming coals of different composition drawn from a number of sources. Bunker blending (after crushing) is one of the most common means adopted for blending of coals in modern coke plants. Suitable appliances are to be employed for primary crushing, intermediate and finer grinding where needed. The types of machines employed for size reduction of different coals should be appropriate to the crushing and grinding characteristics of the coals. Milder crushing of the coals avoiding formation of excessive fines may be ensured by using suitable crushers of the impact type. Modern blending plants often comprise effective screening units heated either electrically or by gas. Efficient mechanical screens have also been developed to treat moist coals. Of primary importance is a suitable device for feeding the different coals in appropriate proportions.

Last but not the least, is the need of a proper mixing device, many types of which are in use in different countries. The purpose of efficient blending will be defeated if the crushed coal is allowed to segregate while they are fed to the service bunker. To avoid this, shuttle conveyors moving along the cross section of the bunker should be used.

Blending of coals with coals of varying coking characteristics and with material such as coke breeze, anthracite pitch, oil, tar etc. is being practised in different countries[7] with different objectives, of which conservation of metallurgical coal and improvement and control of coke quality are the two most important ones.

Blending practice in India

The merchant coke plants in India have one or the other types of unsatisfactory coal handling arrangement. The existing steel plants in the private sectors have underground slot type or overground blending bunkers. The different coals are initially crushed to a size of about 2″ in the primary crushers and then delivered to a common belt before being fed to the final crushers aiming at a fineness of about 80 per cent through 3 mm. The proposed coal handling system for the Bhilai Steel Plant will be more or less similar to the existing practice. The final coal mixture will, however, be crushed to a fineness of 90–92 per cent through 3 mm and after final crushing the coal blend will be delivered to a mixing machine. The Durgapur steel plant proposes to instal the Robins-Messiter system of coal stocking and blending plant after initial crushing of the coal to a maximum size of 2″. The final crushing will possibly again be to a fineness of about 80 per cent through 3 mm. The Rourkela steel plant is expected to have separate arrangement for the crushing of the different coals and possibly to a greater degree of fineness.

It may thus be seen that none of these systems is ideal in respect of thorough blending. While finer crushing is considered essential for some of the Indian coals, it can be mathematically proved that different coals, particularly with high ash as in India, cannot be efficiently blended in the coarse state. This fact and the difference in the crushing characteristics of the various coals demand that *blending should follow final crushing and not precede it.* While the Robin-Messiter system is ideal for blending of ores for which it was originally developed, it is definitely unsuitable for Indian coals even when washed.

Extensive studies carried out on Indian coals for the past few years clearly show that an overall improvement in the coke properties is obtained by finer crushing of the coals. While material remaining on 6 mm size is particularly undesirable, it is found to be invariably beneficial to crush the coal to a fineness of 100 per cent through 3 mm. This can better be achieved by a single crusher using a 3 mm screen and recycling the over-size through the crusher. Alternatively, the coarsely crushed coal after primary crushing to about 10 mm could be made to pass over a 3 mm screen, the minus 3 mm size material taken straight for coking the plus 3 mm size material could be recrushed in a secondary crusher to make the entire material pass through 3 mm size or still finer if so desired. In both these operations the main objective is to crush mildly the softer vitrain and give finer crushing to the harder, durains and inerts.

The objective of effective petrographic separation of the coal constituents prior to their reduction in size can better be achieved in the following manner for most banded coals.

The raw coal is subjected to controlled crushing and then screened, followed by separate washing (to separate the petrographic fractions) of the large and slack coals at specific gravities appropriate to the respective fractions. The cleans recovered from the washed large (which contains more of inert than the washed small) may be given a

[7] Littlechild, J. E. "Coal Blending and Grinding for Carbonising Purposes"—Gas World (coking section). 6th June 1953, pp. 91–99.

finer crushing and the cleans from the washed smalls a coarser crushing, exact conditions being found from tests.

The subject of scientific coal preparation on the basis of the proportions of the individual coals has been ably dealt with in a recent paper. Fig. 12, 13, 14 and 15 show the different methods suggested in this paper for preparation of coals of different crushing characteristics.

Considering the problems in all its aspects and taking advantage of the findings in the Central Fuel Research Institute, the following plan of coal preparation has been adopted at the Durgapur Coke Ovens of the West Bengal Government as shown in Fig. 16. Coal received from three major sources will be differently treated. The essentially bright high volatile coals will be given a coarser grinding of about 75–80 per cent through 3 mm, the medium volatile coals will be crushed to about 90 per cent through 3 mm, but the more durainous and less pure Jharia coals (unwashed) will first be crushed to about 10 mm, screened on 3 mm, the oversize recrushed to 100 per cent through 1·6 mm of which at least 60 per cent shall pass through 0·6 mm and this fraction and the undersize from the 3 mm screen will be stored in the same bunker. The crushed coals from different sources will be separately bunkered and fed to a common belt through proportionating feeders and pass through a mixer before being fed to the service bunker. There is provision for feeding crushed (all through 1 m) high temperature coke dust to the crushed coal before final mixing in a double worm mixer after adding the desired amount of water and 0·5 per cent of oil. Such blending arrangement will make the best use of coals of different coking characteristics. The blended coal will be delivered to the service bunker provided with six discharge pockets to prevent segregation of size.

PREPARATION SEQUENCE FOR COALS REQUIRING HIGH DEGREES OF PULVERIZATION

STORAGE AND BLENDING BINS
↓
IMPACTOR
↓
SCREENS
↓
SURGE BINS
↓
COAL TO BATTERIES

Fig. 12.

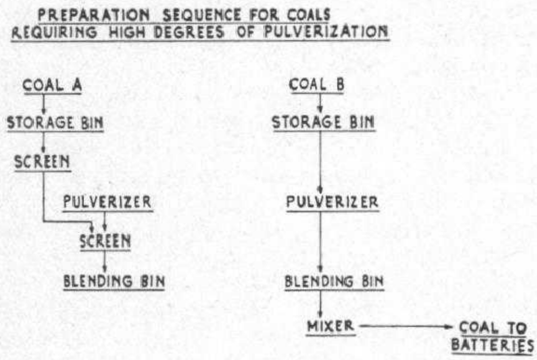


Fig. 13.

PREPARATION SEQUENCE FOR COALS OF SIMILAR PULVERIZATION CHARACTERISTICS

STORAGE AND BLENDING BINS
↓
PULVERIZER
↓
SURGE BIN
↓
COAL TO BATTERIES

Fig. 14.

PREPARATION SEQUENCE FOR COALS OF UNLIKE PULVERIZATION CHARACTERISTICS

STORAGE BIN
↓
PULVERIZER
↓
BLENDING BINS
↓
MIXER
↓
COAL TO BATTERIES

Fig. 15.

Examples of blending

Blending coking coals amongst themselves: The steelworks obtain their coal supplies from 20–30 different sources. These coals range in volatile matter from about 22 to 30 per cent and show even wider difference in the percentage of ash. Thus, some sort of blending becomes imperative for these industries even if the coking mixture consists of hundred per cent coking coals.

Blending coking coals with non-coking and deficiently coking coals: Many essentially bright foreign coals contain an excess of agglutinating constituents which produce large-celled porous and weak coke and have to be blended with other coals deficient

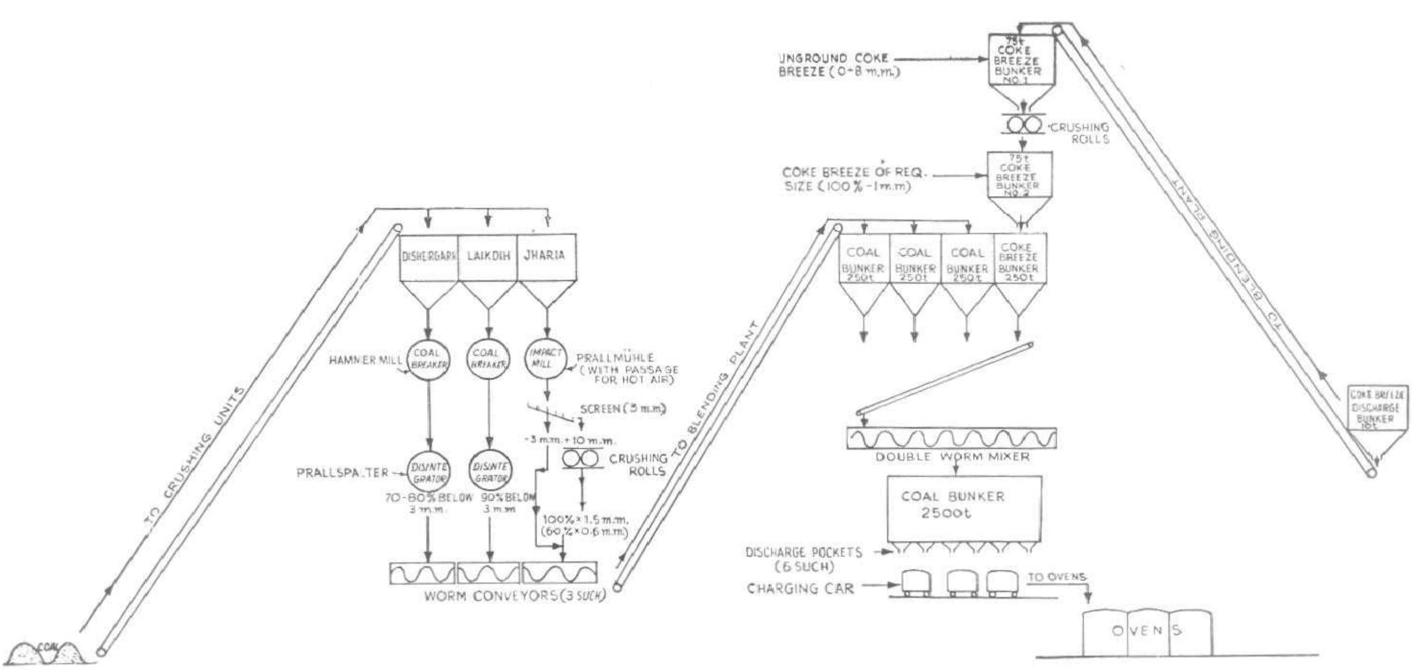


Fig. 16.
Diagrammatic flow sheet of the coal handling plant, Durgapur coke oven project.

in coking constituents or even with inerts used as diluents.

Such blending is also often essential to offset the dangerous swelling pressures that are likely to be developed by certain coals causing damage to oven walls.

Necessity does not normally arise for blending non-coking coal as a precautionary measure against high swelling pressure, because the majority of the Indian coals so far known are free from this adverse feature. Chiefly due to their high ash, there are few coals of coking type which need admixture with other poorer coking coals to control their agglutinating properties.

Nevertheless, studies on pilot plants and confirmed in several cases by commercial oven tests, have shown the possibility of utilising varying proportions of non-coking or deficiently coking coals in blends with normal coking coals without any adverse effect on the coke quality.

Blending with coke breeze : The material of size below ½ in. or ¾ in. is unavoidably produced in all gas and coking industries and often causes difficulty in disposal.

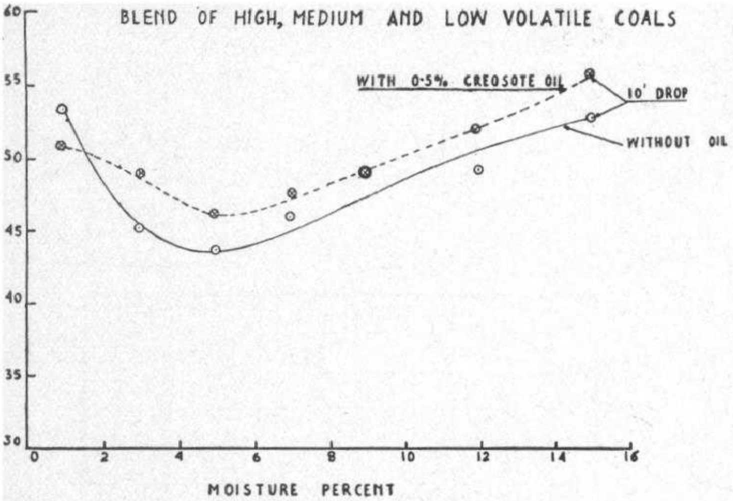
The practice of blending back with the coking mixture, a part or the entire production of the coke breeze (as it is commercially designated) is common in many countries. This is done with the objectives of finding an easy outlet for the material and often to improve the quality of the coke. In fact, in France attempts are being made to produce artificially sufficient quantity of high or medium temperature coke breeze for use in the coke plants since the normal production from coking industries is not enough for their demand.

The Indian coking coals however, chiefly because of their higher ash (even when washed) and lack of excessive swelling and fluid characteristics, do not normally need any diluent like coke breeze or other material to improve the coke quality. Nevertheless, investigations have shown that when crushed sufficiently fine to about 100 per cent through 1 mm, about 3–5 per cent of coke breeze could be added to the coking coal mixer without any adverse effect on the coke quality.

Addition of oil to coking coal mixture : The future coking mixtures in Indian coke plants will consist essentially of a higher percentage of washed but durainous coal. The high moisture in these washed coals and the greater degree of fineness that will be required to obtain coke of the best quality from these coals will considerably lower the bulk density of the charge. Investigation carried out at the Central Fuel Research Institute has shown that the addition of 0·5 per cent of oil to crushed coal in the moisture range of 10 to 11 per cent raises the bulk density of the charge by about 8 to 10 per cent thus increasing the carbonising capacity of the oven by an equal amount besides producing an evening effect on the bulk density which improves the coke quality and by-product yeild. This may be seen from Fig. 17.

Metallurgical coke from high volatile coals

Some of the geologically younger high volatile



EFFECT OF MOISTURE ON BULK DENSITY OF COAL

Fig. 17.

coals from the Raniganj field, for example the Dishergarh seam, carbonised by themselves produce friable, fissured and weak coke not acceptable for normal blast furnace operation.

Investigations at Central Fuel Research Institute have shown that 70 to 85 per cent of these coals can be utilised in blends with specially selected low volatile, lower seam coals from the Jharia coalfield or with char or coke produced from low temperature carbonisation of the high volatile coals or even other non-coking coals. It thus affords a means for utilising two coals none of which by itself produce metallurgical coke.

Industrial significance of the work done

The work enumerated in the paper is of major significance to national planning. In fact, some of the findings have proved to be of great help to some of the industries already existing or are coming into being.

Not only does the work done so far point to the possibility of utilising substantial amounts of the locally available coals in the projected iron and steel plants (for example the Orissa and M.P. coals) but enables, for the first time, the location of carbonisation and iron and steel industries as well as chemical industries in new areas independent of coal supplies from other sources. Based on the findings of the Central Fuel Research Institute, the Durgapur Coke Oven Project of the West Bengal Government has already decided to adopt the technique of selective crushing and addition of oil in their coke plants.

Saving in coal consumption : The net saving of raw coal that may accrue in the Third Five Year Plan requiring 35 million tons of washed coking coal from blending and from the use of smaller size coke in blast furnaces may be calculated as follows :

Total requirements of coke for 15 million tons of steel.

Steel ...	15 million tons.
Coke requirements @ 0·85 t/ton steel	12·75 million tons (metallurgical grade).
For getting 12·75 m.t. of coke.	Coking coal requirements (straight)
+2″ (yield 88% of coke, coke yield at 75%	$\frac{12 \cdot 75}{0 \cdot 80 \times 0 \cdot 75} = 21 \cdot 2$ m.t. if all obtained by washing
	$= \frac{21 \cdot 2}{0 \cdot 70} = 30 \cdot 3$ m.t.
for getting 12·75 m.t. of coke.	Total raw coking coal (straight) at 70% recovery=30·3 m.t.
+¼″ (yield 95% of coke) yield at 75% $\frac{12 \cdot 75}{0 \cdot 95 \times 0 \cdot 75} = 18 \cdot 0$ m.t.	Coking coal requirement (straight)
18·0 m.t. coking blend.	Coking blend.
70% Straight coking coal—	12·6 m.t.
25 unwashed non-coking coal ...	4·5
5% coke breeze ...	0·9
	18·0 m.t.
12·6 straight coking coal at 70% recovery.	=18·0 million tons raw coking coal.
Thus total saving in raw coal is : 30·3—18	=12·3 million tons in raw coking coal.
	=24·6 million tons in *in situ* coking coal (assuming 50% of extraction).

These approximate figures show the magnitude of saving that can be effected even by partial implementation of the recommendations of research.

DISCUSSIONS

THE SIZE REQUIREMENT OF BLAST FURNACE COKE by N. N. Das Gupta and A. Lahiri
SOME ASPECTS OF PREPARATION OF COAL FOR COKING by A. Lahiri, N. N. Das Gupta and T. N. Basu

Mr. L. R. Choudhary, Lurgi Gesellschaft fur Chemie und Huttenwesen m.b.H., Frankfurt/Main, West Germany: Reference has been made by the author and also in papers 4 and 5 to the use of self-fluxing sinter and coke rate of blast furnaces. It will not be out of place to consider here the interesting results obtained by the use of almost 100% self-fluxing sinter burden and various plants. These results are shown in Figs. 1, 2, and 3. Figures 1 and 2 show that in all the four cases a considerable decrease in coke rate with simultaneous increase in production was achieved with the use of almost 100% self-fluxing sinter burden. These results are summed up in Fig. 3 in terms of per cent which can be given as 25–40% saving in coke rate with 45–60% production increase.

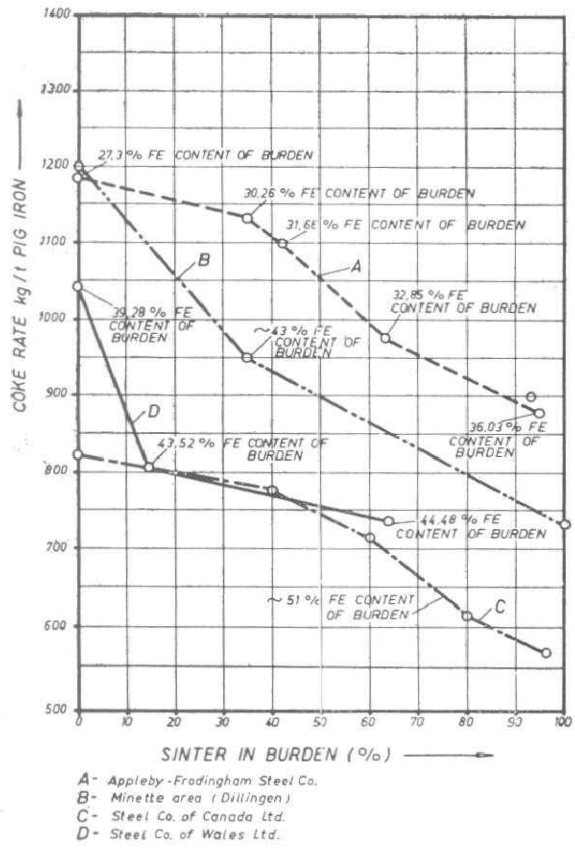


Fig. 1.

Influence of increasing sinter in burden on coke rate for four different blast furnaces.

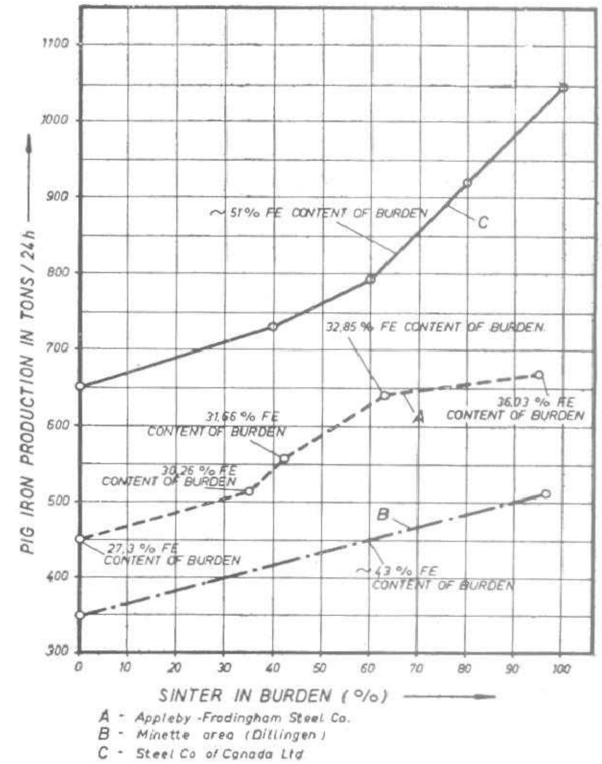


Fig. 2.

Influence of increasing sinter in burden on pig iron production for three different blast furnaces.

Considering these results more and more sinter plants should be switching over to self-fluxing sinter with higher capacities to enable the blast furnaces to work on 100% sinter burden. New plants to be set up for working on this system should be planned according to the flow-sheet shown in Fig. 4, which of course is shown in a very simplified way.

The ores entering the plant by ship or wagons are stored in open yard or bins and then enter the ore crushing and screening system in which the possibility of ore bedding could also be provided. Magnetite ore should be crushed completely whereas hematite ores of good strength and in particle size of 10–40 mm could be sent direct to the blast furnace. The necessary coke and lime have to be crushed below 3 mm. The various raw materials thus stored in the bins will be discharged

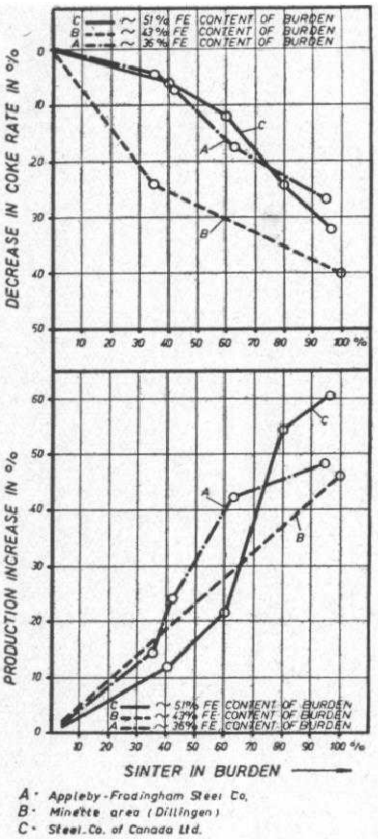


Fig. 3.

Influence of increasing sinter in burden on pig iron production and coke rate (in %) for three different blast furnaces.

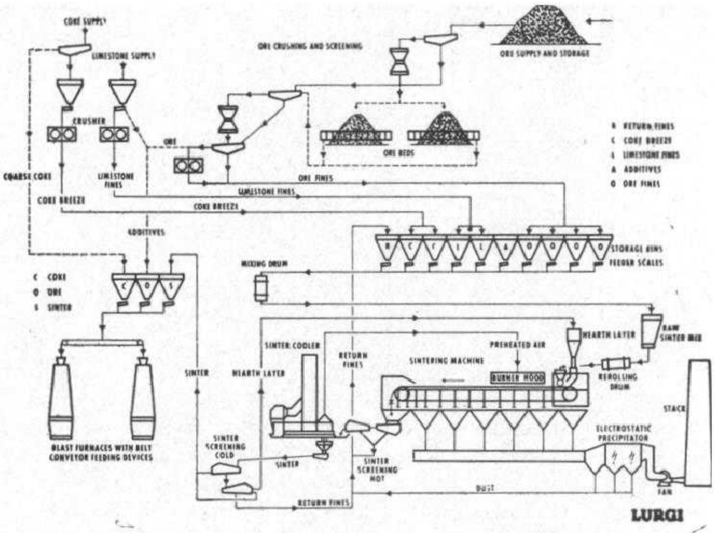


Fig. 4.

by accurate and reliable feeder scale in the proportion to give the desired burden composition. The materials after having been mixed in the most appropriate way found out previously by actual tests will be charged on to the sinter machine which has already received a layer of "hearth layer." Whereas sinter machines of 6–8′ width were used previously 13′ wide sinter machines with over 2,200 sq. ft. suction area are already under construction. The produced sinter after having been cooled by air on a cooler is transferred further by belt conveyors to the furnace high lines or preferably to its top, thus assuring proper handling of the product.