

FUEL RESEARCH IN INDIA.

*By C. FORRESTER, A.H.W.C., F.I.C., Ph.D., F.R.S.E., Fellow of the
Institute of Fuel.*

This is a subject on which much has been written in recent years, even in India, and it is probably hardly necessary, except for the sake of ensuring a proper assessment of the position, to recapitulate the arguments that support the demand for research into the better utilisation of fuel, and particularly of coal. Many scientists and practical mining men also have in recent years stressed the importance of India following the example of almost all other civilised countries and establishing some sort of organisation for this purpose. Messrs. W. H. Phillips (1911), E. H. Pascoe (1924), C. S. Fox (1924, and in many papers since), J. Coggin Brown (1927), H. K. Sen (1927), J. Thomas (1930), C. H. McCale (1930), N. P. Gandhi (1930), N. N. Chatterjee (1930), D. Penman (1932), the author and a host of other workers in this field have, in published papers and in official communications, fully expressed their views on this matter so fundamentally affecting the future prosperity of the mineral industry in general and the iron and steel industry in particular.

What is more important is that so many other countries that have, till recently, regarded fuel research as something to be sponsored by wealthy Governments only, have realised that research is the life-blood of modern industry. Mention need be made only of the research work of the Canadian Bureau of Mines, of the New Zealand Bureau of Mines, and the Fuel Research Institute of South Africa, as well as of similar organisations in China, Japan and the U.S.S.R., to give point to the remark. South Africa's recent action in establishing a Fuel Research Institute by utilising the funds collected by the formerly-existing Coal Grading Board is peculiarly interesting to us in India, especially as Africa's coal problems so closely resemble ours, as do her financial problems.

Let us assume, then, that the establishment of properly organised fuel research must come in this country and examine the problems waiting for us to deal with.

Much attention has been publicly focussed on the pressing problem of conservation of our coal resources and the recently-issued Report of the Coal Mining Committee has brought the whole subject to the front. In their recommendations the Committee have suggested the establishment of a 'Coal Research Board' but have left its functions undefined. 'Coal' research may mean safety in mines research, which aids in effecting conservation, or fuel research which, by making utilisation more efficient, more directly aids in effecting conservation. One of the problems that has been more stressed than any other in public discussions of this subject has, of course, been the

conservation of the country's reserves of coking coal. The whole future of the industrial life of India is bound up with the future of these reserves and obviously it is only proper that we should do anything that can be done to reserve for their 'proper' use those coals at present used for other purposes than those for which they are best suited. But there are many other problems, some of them equally important, others of apparently minor importance but none the less essential in the part that their investigation may yet play in the proper utilisation of India's coals.

The following list is extracted from a Memorandum prepared in 1934 by the author and submitted to the Government of India in support of a proposal to establish a Fuel Research Department in India:—

1. Systematic physical and chemical survey of the coals of the various coalfields in India with special reference to—
 - (a) specific gravity as related to ash content,
 - (b) proximate analysis (by proper standard methods),
 - (c) coking power,
 - (d) chemical analysis of ash,
 - (e) ultimate analysis,
 - (f) fusibility of ash and tendency to clinker,
 - (g) separation of banded constituents and other rational analysis.
2. Nature and amount of volatile matter expelled from coals at various temperatures, with special reference to manufacture of good quality soft coke for domestic purposes.
3. Laboratory- and medium-scale investigations on washability of second grade and low grade coals and of slack coal.
4. Visual investigation of nature and distribution of mineral matter in coal by X-ray examination. (This refers to incombustible mineral matter.)
5. Large-scale briquetting tests, especially with a view to investigate the possibilities of briquetting without the use of a binder.
6. Investigation into the causes of spontaneous combustion of coals in Indian coal mines.
7. Conversion of Indian coals into oil.
8. Extension of the use of Indian coals in gas producers.
9. Valuation of Indian coals with a view to encourage purchase and sale to specification and on analysis.

To the above may be added others to which reference is made below. The following comments upon the above are offered as a stimulus to discussion on the question and with a view to elicit the opinions of others as to the relative importance of those various suggested lines of research and our ability to prosecute them in India in the most efficient manner possible.

1. *Systematic survey of the coals of India.*

This has, of course, been already done geologically and, by reference to existing analytical information, chemically but it has not been done systematically in reference to sub-heads (a) to (g). The Department of Scientific and Industrial Research of Great Britain has for the past few years been engaged, through the Fuel Research Board and the associated universities and colleges, on a wholesale survey of this nature and already the results have proved to be of great practical value to industry. Apart from the scientific value of such a comprehensive survey, the practical value of the knowledge gained by accurate and standard methods of investigation cannot be over-rated, especially in these days when so much in India depends upon export trade. Special reference might be made to the great interest recently taken, by overseas buyers of Indian coal, in the chemical composition of the ash and its fusibility, with reference to possible clinker trouble. The amount of information regarding fusibility is somewhat meagre and it is to be feared that much of the equipment available in the country for this work is not designed to give accurate information comparable with that supplied by standardised apparatus used, say in Britain or America. As for the chemical composition of Indian ashes we are in almost as bad a position. A few analyses of Indian coal ashes are quoted in the publications of the Geological Survey of India and special mention may perhaps be made of the most recent contribution by Mazumdar given before the last session of the Indian Science Congress and published in full in the August 1938 issue of 'Fuel in Science and Practice'. The industry badly wants much more of this work to be done and a determination of fusibilities of the same ashes, in both oxidising and reducing atmospheres is equally desirable.

A similar investigation into the fusibilities of ashes of mixed coals is of equal importance owing to the failure on the part of both suppliers and consumers to realise that mixing coals entails grave risk of clinker trouble due to the almost certain lower temperature of fusion of the mixed ash.

A branch of this work that is of great importance both from the purely academic point of view and for the purpose of classification and correlation of coals is 1(e), ultimate analysis. Especially in respect of the determination of the amount of oxygen in Indian coals we are sadly deficient in information about their composition. The determination of oxygen in a coal is an extremely difficult one that only most experienced fuel technologists can with confidence undertake and bound up with it is the careful analysis of the ash, with a view to develop a formula for Indian coals corresponding to Parr's Formula, in order to calculate the amount of mineral matter in coals from a study of the amount, and chemical nature, of the ashes. The practical benefits of Seyler's classical work on classification of coals cannot become available to us in India until this work is undertaken and carried to a successful conclusion.

2. *Volatile matter and carbonisation at different temperatures.*

On this important subject, also, little has been done. The Indian Soft Coke Cess Committee has had some work done and a large series of Jharia-Barakar coals has been investigated by the author with reference to distillation products obtained at temperatures varying from 300° up to 950°C. Some of these results have been utilised in aiding the further investigations, but none of them has yet been published in detail (a defect that it is hoped will be remedied shortly). Prof. Roy, President of the Geology Section of the last session of the Indian Science Congress (Lahore, 1939), quotes the results of some similar distillation experiments carried out by workers at Calcutta University. Apart from these figures it is doubtful whether any systematic work has been done. In these days when improvements in methods for manufacturing soft coke, and low temperature distillation processes, are much in the public eye, it is highly desirable that the work done so far should be supplemented without delay.

3. *Washability of coals.*

The only work known to have been done in India on this subject has been by (a) Randall in 1924, and (b) Forrester in 1936. The former was limited to a few experiments using a froth flotation experimental plant and without constructing fully informative washability curves, and the latter was confined to an examination of coals known already to be comparatively clean and free from stone bands, though complete washability curves were constructed from the laboratory work.

Although the latter dealt with Jharia coals (and that work has been published) and with a selection of Raniganj coals (the results of which have not yet been published) only the fringe of the subject has been touched. An extensive washability survey of run-of-mine coal and 'whole of the seam' coal is highly desirable. The industry cannot at present be said to know what possibilities there are in the cleaning of coal in India.

4. *X-ray visual examination of coals.*

This work is an adjunct of the preceding, *i.e.* washability, and need not be enlarged upon here except to explain that it ought not to be confused with the more academic matter of examination of the internal molecular or crystal structure by means of X-rays.

5. *Briquetting.*

The importance and various aspects of briquetting have been dealt with by the author in a separate contribution to the *Symposium* and will not be dealt with here.

6. *Causes of spontaneous combustion.*

This subject has engaged the serious attention of the Department of Mines for several years now and would in all probability be considered to be within

the scope of a Safety in Mines Research Department, and the subject of safety in mines is dealt with in a separate contribution. It is worth while pointing out, however, that the results of some of the work of a Fuel Research Department would undoubtedly tend to throw much light on this important problem, so vitally affecting the industry at the present time.

7. *Conversion of coal into oil.*

This is a subject on which information regarding Indian coals is undoubtedly required. But the author is inclined to the view that work on this problem can very well be delayed until we have more information regarding the progress in other countries, as comparatively simple tests, indicating the 'rank' of the different coals, can give almost all the information wanted with reference to any particular coal. A comprehensive laboratory study of a large range of coals with reference to this subject seems, to the author, scarcely to be justified at the present stage. Other workers, however, may not be in agreement with this view.

8. *Use of coals in gas producers.*

It is questionable whether any completely separate series of investigations into this subject is really necessary. But information regarding Indian coals is required to judge the suitability for their extended use in gas producers, and the information would be obtained from the results of 1(b), 1(c) and 1(f) above.

9. *Purchase and sale to specification and on analysis.*

This is partly within the scope of the economist but the scientific investigator should interest himself in the devising of suitable practical formulae likely to be acceptable to various industries with a view to extend the adoption of more rational methods of valuing coals. The author realises that the extended adoption of the specification system would ultimately tend to dispense with the present grading method but the industry would benefit ultimately, and the cause of conservation would be immeasurably advanced.

One major problem likely to be a fruitful subject of research is that of *blending of coals* with a view to use a greater proportion of non-coking or weakly-coking coals for coking purposes, as well as to lessen the trouble sometimes experienced with coals of high swelling power that, on account of insufficient subsequent contraction in the coking process, cause serious deformation and ramming trouble in coke ovens. This is also a subject that could better be done in the country and should be undertaken with little delay.

Full-scale experimental work has been carried out on this subject in India by Lathbury and Marshall in 1919 and by Lancaster and Marshall in 1927. In their experiments Lathbury and Marshall tried the effects of mixing different proportions of good quality Giridih coking coal and upper Raniganj non-

coking (or not good coking) coals, and Lancaster and Marshall included in the scope of their later work poor coking coals from the *lower* Raniganj measures as well as from the Bokaro and Karanpura fields. [A full report of the results of both series of experiments is given by Fox in *Rec. G.S.I.*, LXI, 1928-29, 294-314.]

The results of these experiments conclusively show that there is scope for further investigations, both in the laboratory (using the various types of apparatus for testing swelling and contraction) and on a large scale by coke oven tests.

The foregoing remarks apply chiefly to research on the preparation and utilisation of coal. India possesses vast *additional sources of power, both actual and potential*, for example, wood and other vegetable substances and the various substances that can be obtained from them either by distillation or by fermentation. Special reference may be made to the work of various investigators at the Indian Institute of Science in the direction of hydrolysis of waste carbohydrates such as rice straw by dilute sulphuric acid, followed by fermentation of the sugar produced. The treatment of other waste substances (including such pests as the water hyacinth) has also been suggested and much sporadic experimental work has been done. There are in India countless hundreds of similar potential sources of alcohol that may yet be profitably investigated.

The author would also point to the great possibilities of the more extensive use of wood and wood charcoal (especially the latter) as the source of producer gas for gas-driven internal combustion engines, *i.e.* motor cars driven without petrol. The wood-gas motor car is now a practical proposition. India, with the problems of vast distances and the accompanied problem of high railway freights, might well utilise her otherwise useless woods (*i.e.* useless as timber) more efficiently as a source of fuel.

The spade work on *hydrolysis and fermentation has already been done for us.* All that is required is to apply the well-known facts to the raw materials available. Here is another wide field of investigation for the research worker.

How, then, is this great programme of research work to be accomplished? The question has been asked over and over again, in public meetings, at annual dinners of scientific societies, in informal discussions among mining men and their more academically scientific friends, and the answer seems never to be forthcoming. The coal industry, when it has shown signs of interest in the subject, has maintained that it is the affair of Government. Government, when challenged on the matter, have said that the industry should first make a move. The result is stalemate, except that individual workers, both among the important coal mining companies and among individual scientific workers in technical colleges and universities as well as, of course, the staff of the Geological Survey of India, have materially contributed to our knowledge of the composition and properties of our coals.

The trouble is that the work has not been carried out in a systematic manner. There has, naturally, been no systematic co-operation or planning in

the work so far, *i.e.* co-operation between different workers and, as stated elsewhere ('Methods of Analysis of Coal in India' in this *Symposium*), much of the published work—perhaps as much as 90% of it—has been done by methods that render it almost certain that it will have to be done over again.

The remedy is, in the opinion of the author, *either* to establish a non-official all-India scheme of co-operation between fuel technologists and other workers in the field, with a voluntary (and voluntarily accepted) central distributing bureau for co-ordinating the work of the various persons taking part in the scheme and for distributing systematically samples of the various coals that would be examined, so as to avoid overlapping and the loss of valuable relative information about the same coals from different sources; *or* to induce the Government of India to establish, as soon as funds permit, a central Fuel Research Station.

On the assumption that it would be possible, as it is found possible in Britain, to obtain the co-operation of workers in technical colleges and universities (as well as of trade organisations if formed) the second alternative appears to the author to be preferable.

The requirements of the industries likely to benefit from this work cannot be adequately met by the results of work carried out solely in universities and colleges, the staffs of which have other onerous and distracting duties to perform. If the work has to be of first-class quality and if much overlapping and unsystematic work has not to be undertaken, a full-time central controlling authority must ultimately be appointed. The expense may in the beginning be just what we care to limit it to, provided, of course, that a reasonable minimum is conceded, and the work that can be undertaken would depend almost directly upon the amount of funds available.

The apparatus and equipment required for most of the subjects suggested is not unduly costly. Much of it could be made immediately available from various sources until such time as the indications of the results likely to be achieved justified permanent establishment of the central station. If a purely organising and administrative central authority were established, seeking co-operation, and helping in the direction of the work, and of course, financing the publication of the results, a total annual expenditure of under Rs.50,000 per year would probably be ample. If a centre were to be established in or near one of the coalfields for a central laboratory and library, still working in co-operation with other laboratories throughout India by a distribution of work in which different workers were interested, an initial expenditure of about Rs.25,000, with an annual recurring expenditure of about Rs.50,000, would be sufficient. When it is remembered that the magical figure of 'a lakh of rupees' is merely about £8,000 the corresponding figure of over £80,000 spent by the British Government on the Fuel Research Board, as well as the large sums separately spent by various coal trade organisations on research work, make our present proposals acquire considerable merit on the grounds of modesty.

The views of the various universities, technical colleges, Government departments, and individual workers on the possibilities of co-operation might well be invited, in order to enable the Government of India to judge to what extent the institution of a central organisation would be feasible.

In the meantime the most urgent need, in the opinion of the author, is a reliable central research bureau, kept up to date by an efficient fuel technologist with the help of first-class clerical staff. As the years go on the amount of valuable information that is accumulating is increasing and it is daily becoming more and more difficult to ensure that one has access to all the important literature on any one subject. (This is a problem not exclusively that of the fuel technologist.) Such a central bureau can be established at little expense. But if it is established it must be comprehensive and complete. No half measures are worth the trouble expended on them.