COAL CLEANING AND BENEFICIATION IN INDIA.

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The subject of cleaning of coal is, in India, one that has probably received a greater amount of discouragement than any other affecting the winning and utilisation of coal. Comparatively little has been done in the matter of either research work or practical experiments. As far as Indian conditions are concerned, therefore, there is unfortunately little that can with confidence be said on this subject and what little is known mainly concerns Jharia and Raniganj coals. In this connection Mr. Innes' remarks in his paper (this *Symposium*) on the marketing of coal in India are worth special attention.

The beneficiation of coal may be effected in several different manners, for example by hand-picking underground or (more usually) on the surface, by carefully planned screening, by 'washing', *i.e.* by removal of heavy (and therefore high-ash) material by treatment in currents of water or by liquids of selected specific gravities, by 'dry cleaning', utilising various physical properties of coal and shale or stone such as coefficient of friction, elasticity, resilience, etc., and so on. All these processes are based on the assumption that stony material occurring along with coal is to a large extent separated from the better quality coal in the ordinary processes of mining and the subsequent normal preparation of the coal for the market.

Most practical mining men in India assert that the bulk of the ash-forming mineral matter in Indian coals is much more intimately mixed with the coal substance than is the case in countries (*e.g.* Britain) where coal cleaning is extensively employed. To a large extent that is true and it must be accepted as an unfortunate fact that coal cleaning methods are much less likely to meet with success and universal adoption in this country than in most other countries. But other countries possessing coals very similar to those found in India have taken up this matter seriously and the mining industry of India will be committing a grave mistake having effects lasting for many generations if it does not maintain interest in this subject.

As with so many other problems that interest the scientist there are serious economic aspects of this question. We have not yet, however, reached the stage at which the economics of the matter can be profitably pursued and it is not at present proposed to deal with them. For the purposes of this note, therefore, we shall deal with the scientific aspects and such practical aspects other than economic that the information available justifies referring to.

There is already in operation in India a kind of coal cleaning imposed, in a sense, on the industry but it is the most expensive and least efficient coal cleaning in the world. The conditions in which the Indian Coal Grading

Board issue Grading Certificates are such that all colliery concerns that desire to obtain, and retain, such certificates must exercise a wholesale selection of the better portions of seams and also a considerable amount of hand-picking both underground and on the surface. It only requires a few visits to selected collieries in both the Raniganj and Jharia coalfields to realise the extent to which shale and stony coal *do* exist in a separable form. The author is inclined to wonder whether the coal mining industry realises the full significance of this fact when considering coal cleaning. But there is a more important aspect of this that deserves greater attention that it receives. It is an inevitable consequence of the Coal Grading Board method of grading coal that, in order to retain a certificate, certain lower grade portions of seams are left underground. A small fraction of one per cent in ash or calorific value may frequently decide in favour of or against a considerable proportion of our coal reserves and the slow adoption of the principles of buying and selling according to specification, allowing for penalties *and premia* for departure from the specification, cannot but militate against the adoption of proper cleaning processes.

The present author has not collected data regarding the results of hand-picking and his figures relating to portions of seams left unmined on account of the practical and economic difficulties at present in the way of the adoption of modern methods are insufficient to justify quotation. This reference may, therefore, be taken as an invitation to practical mining men to give the rest of the industry, and scientific friends of the industry, fuller information that may aid in furthering the cause of coal cleaning and thus serve the industry as a whole.

So far as regards the more commonly used methods of cleaning, particularly 'washing', little or nothing has been done in India, or if it has been done the literature does not help us much. One firm has in recent years carried out practical experiments in dry cleaning, using the Berrisford separator, with encouraging results. But dry cleaning processes are not generally likely to be so suitable for Indian coals as wet processes. The differences between 'coal' and 'dirt' or 'stone' are not so clearly defined. The gradations between the various qualities of coal are too gentle and it is in the opinion of the author doubtful whether dry cleaning methods are ever likely to be favoured.

One special method of cleaning of coals utilises the principles employed in the froth flotation of ores and this process has also been tried, though only in the laboratory, for the treatment of Indian coals. The work is reported on in the *Records of the Geological Survey of India* (Vol. LVI) and was carried out as long ago as 1924 by W. Randall. Compared with more recent investigations this report cannot now be regarded as affording us much reliable information about the cleaning of Indian coals. Modern methods of investigating the possibilities of cleaning coals require the construction of washability curves. Much useful work on this subject awaits the investigator and it is not unduly difficult to do.

Perhaps the only published results of such investigations are those of the author, appearing as part of a paper on the Barakar Coals of the Jharia Coalfield. (*Trans. Min. Geol. Inst. Ind.*, XXX, 1936). The work therein recorded relates to Jharia coals only, though a similar investigation (the results of which have not yet been published) had then been carried out on a selection of Raniganj coals.

Along with this work on washability the author also examined the same series of coals by X-rays with a view to indicate the manner of occurrence of the high-ash material in the coals. The results of these two lines of investigation can appropriately be referred to together. Considerations of space in publication and time at our disposal in this *Symposium* make it desirable to summarise conclusions rather than to develop arguments.

Apart from wide stone bands and other easily recognisable high ash bands in seams, high-ash portions of Barakar coals cannot be readily removed from large size or so-called 'steam' coal. In this respect, of course, Indian coals do not differ very seriously from the best British coals. Most profitable washing processes do not apply to large size coal. It is when we come to examine the possibilities in respect of the smaller sizes of our coals that the difference is striking—and no doubt discouraging. Large rubble coal obtained in the ordinary course of mining in say Britain may, and frequently does, contain innumerable pieces of stone and/or high-ash material. This can be easily separated by almost any simple washing plant. The same cannot be said, in general, about Indian coals, or, rather, it cannot be said about rubble of the same size, and it will probably have to be admitted that it cannot at present be said about any coal above say 2-inch in size, always excepting, of course, wide stone bands, etc., already referred to. The abandonment of the present grading system would in all probability completely alter every aspect of this question.

It is when we come to the smaller sizes of screened coal that the possibilities of cleaning on a large scale become more attractive. Again excepting the wide stone bands, etc., at present deliberately left *in situ* or hand-picked underground, we find that even the carefully selected coal can to some extent yield up varying proportions of high-ash material. The washability curves of 23 Jharia coals appearing in the paper referred to above indicate that the smaller sizes of our Indian coals might respond to normal washing processes. In considering the practical implications of these curves it must be kept in mind that they record the result of investigating crushed *clean* run-of-mine coal already selected for despatch as comparatively good coal. If the methods of winning were such as to include a greater proportion of stony bands and high-ash coal, for separation on the surface, the slack coal would in all cases have shown a remarkably higher degree of beneficiation. Here is another direction in which much useful experimental investigation awaits the research worker. The results of such work would go far to change the whole attitude of the mining industry to the subject of washing.

There is a subsidiary aspect of washing of coals in India that has not received the attention that its importance—its *practical* importance—merits. It is an aspect that only the iron and steel manufacturer fully appreciates. There is no surer source of inefficiency and waste in blast furnace operation and foundry work, and probably to a less extent in steel manufacture, than a supply of coke of *widely varying* ash content. Alternatively stated, it pays the blast furnace manager to work with a comparatively high-ash coke whose ash content, and the chemical nature of whose ash, do not *vary* appreciably over very long periods, rather than to work with a large series of cokes of different quality the ash contents of which are all comparatively low but vary within several points per cent as well as chemically.

The practical results achieved in the laboratory by the author were, as already suggested, not all encouraging. As much as 25 per cent to 30 per cent of the crushed or slack coal had to be rejected to lower the original ash content by one-quarter of its value. But there were cases where as little as 5 per cent rejection effected the same beneficiation. Remembering again that these tests were carried out on comparatively clean crushed coal the conclusion that appears to be justified is that washing of slack coal obtained by mining the whole of a seam (without rejection of coal of intermediate quality in order to 'get into the grade') would undoubtedly give excellent results, and of course add to the total output.

Another result of such lowering of ash content, quite apart from the *amount* by which it is lowered, is that even a small reduction in ash content may be accompanied by (in fact, due to) the removal of highly injurious constituents of the ash, especially sulphur compounds as these occur in the *heavier* fractions removed in washing.

Yet another practical aspect of this subject is concerned with screening and the accumulation of vitrain in smalls. It is now well recognised that some Barakar seams, especially, in the opinion of the author, those in the Jharia coalfield, contain unusually friable vitrain. In the ordinary course of mining, this vitrain naturally becomes liberated to a degree corresponding to the extent to which the coal is ultimately broken up for despatch. The greater the amount of rubble produced the greater the amount of vitrain that is likely to be liberated. Vitrain has always a much lower ash content than any other portion of coal; the author's experiments give ash contents as low as 2·5% for vitrain of specific gravity below 1·3. (One sample from No. 14 Seam in the Jharia field gave the unusually low figure of 1·525% for ash.) It is obvious that an accumulation of such low-ash material will have a beneficial effect on the slack coal among which it accumulates. The lower ash content of slack coal as compared with the steam coal from which it is derived and with the rubble (which has consequently, of course, a *higher* ash content than the steam coal) is a well known fact. But there is another interesting fact that merits attention. This enrichment of small coal does not proceed indefinitely. If a careful screening test is carried out on run-of-mine coal,

especially coal that has been machine-mined, cutting having partly taken place in an undulating stony floor, the very finest material, *i.e.* dust finer than say 90-mesh, may have an exceedingly *high* ash content, *e.g.* 60–65%. Such high-ash dust can be removed by pneumatic methods, *e.g.* by allowing the fine coal to fall down a series of inclined shelves, between which a current of air is blown or sucked by an exhaust fan. The whole operation is carried out in a suitably designed tower and the air rising to the top carries with it the high-ash dust. The process is well known as 'de-dusting'. De-dusting of coking slack may yet prove in this country to be a useful adjunct to the other coal washing operations, and is in fact likely to be adopted more particularly in connection with the cleaning of coking slack, not only to reduce ash but also to aid in draining of the washed product and to avoid slurry problems.

In opening discussion on this kind of subject it is presumably not desirable to attempt to indicate what different kinds of industrial plant are likely to be adopted in India should coal washing become a common practice. But the preliminary study that has so far been possible suggests the likelihood of the Reolaveur type of washery being particularly suitable for the treatment of coking slack in this country. The author favours investigations by the coking and iron and steel industries into the possibilities of installing two or three collecting centres for washing slack by a plant of that type prior to shipment to the coke plants. Alternatively one of the more recent specific gravity processes (e.g. chance) offer definite attractions, as they can be applied to unscreened coal.

In conclusion of this brief summary of the position it may be suggested that much useful practical work can be done on Indian coals to provide the industry with statistics and the results of laboratory investigations, and especially work on run-of-mine coal from the whole of a workable seam, as well as on the slack from the same seam. Fuller detailed information is required on this most important and essentially practical problem.