Coal Beneficiation — Application of froth flotation

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I shall try to highlight the growth of beneficiation in coal and leading to the need for adoption of flotation circuits. Beginning in early 50's when the upper horizon with low ash and low near gravity materials were mined, all either jigging or heavy media baths for beneficiation was found effective. The fines were taken out before the feed into the cleaning circuit. The fines were of low ash and were invariably re-mixed. Circuits were simple and operated well.

During late 50's, mechanised coal getting started followed by undercuttings and blasting. The fines proportion increased. Degradation of coal and even of contaminants started taking place. The bye passed fines were no longer low ash and when mixed with clean coal started pushing up ash. With gradual exhaustion of these seams, we had to go into lower horizons and that made the situation worse. Following nationalisation of coal, some of the practices that adopted earlier of selective mining of seams had to be given up for conservation. For example 10th seam in the prime coking coal area where one section of about 10-12 feet was extracted, the rest of the seam which is almost 50 feet thick was hardly worked, not for coking coal in any case. Now the full seam has to be worked. In many other places, the coal became dirtier, and it was no longer true that the fines were low in ash. This inevitably led to use of flotation and the first flotation unit was installed at Kathara.

The system, in absence of experience, could not be effectively utilised. It is now adopted as an integrated part to the new beneficiation plants i.e. Sudhamdih, Monidih, West Bokaro II and Nandan Washery.

The washeries with no fines washing facility found, they are unable to meet the quality parameters. These fines, have either to be beneficiated or mixed with the middling and sent out. The latter option would mean loss of good coking coal. We have to only evaluate the money we are loosing either by bleeding slurry out of system or pushing it into middlings, the amount will run into several crores every year and which the coal industry could not really afford. Adoption of beneficiation of fines, if taken earlier would have obviated need to import coking coals. Each million tonne coking coal import costing around Rs. 100 crores, modification of washeries could well be completed within this amount.

Now I would only get onto some of the factors which influence performance of flotation cells based on the experience of some of the units.

Quality of Coal :

Coals from shallow depths, open cast, oxidized coals and from long held stocks at Pit Head, the yield drops. Oxidation dilutes the hydrophobic selectivity of coals. The nature of minerals also make some impact.

It has been our experience that on occasions, float recovery drops suddenly. Later investigation revealed that coal was heat altered or from opencast faces which had remained exposed over long periods. Withdrawal of these coals or variation of dosages correct the position.

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Size :

In many cases we have been pushing the +0.5 mm to the flotation circuits. It could be due to the damage of the screens in feed route to the circuit. The result is that all this oversize coal does not float and goes out as tailing. The tailing ash drops, yield becomes low with resultant waste of good recoverable coking coal.

Size Variation :

Even 0.5 mm to near zero sizes is too wide a range. At one time, we thought it was good range. But when we break up into sub lot through screen analysis and look at each fraction, we find, these contaminants are concentrated in certain fractions. If we want to treat them all, there is a problem, particularly, when we put in a very wide range, the finer particles having larger surface for a given mass, take a large amount of collector hydro-carbon and float much better than the heavier particles which really get starved out. Therefore, the yields go down.

There are two possibilities — one is to classify these two and treat them separately. The second is to classify and take out the ultrafines which are high in ash and poor in carbon content and eliminate them. But that constitutes a loss. The point that I wish to make is that no longer -0.5mm down to zero can really be washed in one stage, because losses are high. This needs to be studied for feed from each washery.

Pulp Density :

Again in many of the plants the pulp density is not controlled. I have seen the plants that are working at pulp density of 5% or less, giving poor yield and lot of material going in the tailing as ultrafines or heavier pulp densities of 20 and above which do not give time and opportunity for the material to be collected by the collector and floated up. That again needs a very close control.

Dosages :

Anytime a problem occurs, the first attempt is to put more collector and more frother. I have seen sometimes the froth coming is so stable, it hardly breaks and it will flow down for a nice fine layer on the thickener itself. The quality, the type and the quantity of both collector and frother have to be experimented and a proper combination and optimal dosage found out for each type of coal we are feeding in. We should try to work out a series of dosages and each one will have to be determined on its own.

Contact time :

There is another element of contact time. I have seen in some cases that the first 15-20 secs, 80-90% of the material gets collected and froths up. Thereafter the subsequent cells in series, you can put more of collector and frother, the yield is not going to come up. But there are coals which do not froth up and do not come up quick enough. In that case it is much better to increase contact time and may be have to give secondary feed of the collector and frother itself. The point I wish to emphasise is contact time to be studied for each type of feed. There is no one single formula.

Optimisation :

Then what are the other possible areas that need attention ? To my mind it is important, we study beneficiation of different fractions. Depending on proportions of each size, we determine ash reduction points, so that when combined we get the highest yield. If we do not do it, probably we are not getting the full coal out and it is not uncommon to see in some cases yields are low and ash in tailings equally low. In other cases the yield is high, the tailing ash is higher, but in practice there is a wide variation which keeps on taking place.

Summing up :

There is a need to control the pulp density and we must instal proper density controls and controlled conditioning must be done. In

another case we have found most of the cells are not aerating properly. The pressure is not being maintained. The result is we never got the best of recovery. We simply had the churning up, but it did not aid in flotation. This is another area which has to be properly checked up. When the ultrafines in the feeds become very high, because of the larger surface exposure and in some cases the ultrafines getting contaminated with the base material also tend to pick up large hydrocarbons from the collector. This results in starving of the material we are interested to float up. This shift of hydrophobic to hydrophilic transition need to be kept under observation. Otherwise we are going to have heavy losses in the process. Without really getting analysis and finding reasons, if we are going to say that the system is not fully successful, then we will be probably missing the maximum potential of the particular system.

We have been trying to acquire some insights of the flotation processes, but more studies have to be conducted on responses of different coals to flotation and influence of various factors which so far are largely being done emperically, at least in the field, may be the institutions are doing better.

Alternatives :

Likewise there are few promising developments in the treatment of —0.5 mm fines, spherical oil agglomeration is one approach, where the coal particles adhere to the oil expelling water and isolating the mineral matter from carbon really getting almost all the coal out of the system. In such cases the yields could be very high, almost 90% as against 45/60% recorded in flotation.

Attempts have been made to separate 0.5 mm to 0.1 mm and clean them in deep throated cyclones, and leave only the extra fines (—0.1 mm) for flotation circuits. This needs to be really studied and worked out, while we have seen the work is being done elsewhere. I am not aware if we have done much of the work, but lot more needs to be done.

There is another area, so far we have not gone in, is chemical leaching, particularly where we want much lower ash coals for specific purposes. One of such purpose I can see is for direct reduction process. We all talk of new reduction process and non-coking coal as if high quality non-coking coal is available in abundance. They just are not. Therefore, grinding coal to the same level, may be we need to leach and briquet it in some cases, where fine powder cannot be used. It is essential to look at these areas. The point I want to make is that the mechanised winning of coals had added and will continue to add contamination and degradation of coals. The degradation has already adversely effected the ash, in the fine coals tested, and system of flotation extended already to our washeries. The results obtained so far have not been consistent. These have varied with high yields to low yields, and low ash in tailings in many cases. Close study of coals, classified feeds, correct dosages of collector and frother, together with proper conditioning is essential to get the best pay-off. R & D efforts to improve the performance of flotation therefore must continue. But flotation besides being expensive, does not respond fully to full recovery of coking coal contents. Lot of it is lost to tailings. There is a strong case for better understanding for improved exploitation of flotation. There is an equally strong case to develop alternatives to it either spherical agglomeration, chemical leaching or any near process which will respond to.

I have not deliberately given much of the data because our own observations are not yet complete. We have been working on number of coals trying to get more insight to the process. My objective has been to slate my views to enable us to take a look at the process in so far as it applies to coal as its application is increasingly extending.

I thank you gentlemen for the opportunity to put my views across to you, based on experience on several Flotation Units.