Impact of Flotation Machine Characteristics on the Performance of Fine Coal Beneficiation (-0.5mm & -0.25mm) – a Case Study of Tatasteel

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Abstract

Tatasteel coal washeries at West Bokaro are designed to treat (+) 0.5mm in dense media cyclones & (-) 0.5mm in mechanical type flotation cells. Typically, ~20% of the raw coal feed reports to the flotation circuit. Through several plant audits carried out for the fines circuit, it was established that there is a scope for yield improvement in the fines circuit by ~3–4% on raw coal basis w.r.t the maximum theoretical flotability of the coal. Flotation is a complex process controlled by factors which can be divided into three facets: coal characteristics, chemistry and machine characteristics. Factors within the coal and chemistry areas are dynamic and hence, need to be dealt with by personnel on an ongoing basis in normal plant operations. One of the most important characteristics of any flotation technology is air bubble generation and the size of air bubbles produced as this controls flotation kinetics and also, it dictates the carrying capacity of the machine. Another crucial component is how the machine effects collision and contact between air bubbles and particles. Apart from mechanical type flotation cells, the most popular flotation technologies elsewhere are Jameson & Column flotation. Jameson cells hold an edge over Column & mechanical flotation cells in terms of providing better kinetics, low footprint, lower operating & maintenance costs.

In the present study, authors have tested West Bokaro coal in conventional mechanical & Column flotation cells at Tatasteel R&D whereas testwork in Jameson flotation cells was carried out at University of Queensland (Australia) for (-)0.5mm & (-)0.25mm size fractions .Results for (-)0.5mm size fraction show that Jameson cell gives 78.5% yield , Column cells give ~71% compared to 65% in mechanical cells on unit basis. Results for (-)0.25mm size fraction show that Jameson cell gives 87% yield , Column cells give ~83% compared to 80% in mechanical cells on unit basis. It is evident from the testwork carried out that Jameson cells are capable of giving higher yields at the same product ash and based on the same ,a pilot scale installation of Jameson cells has been proposed to validate the lab findings.

Keywords: mechanical cells, column cells, jameson cells, unit yield

Introduction

Tata Steel West Bokaro coal washeries came into existence in 1948, as an independent coal company, managed by M/S Anderson Wright. Tata Steel acquired the Company in 1956 to meet its requirement of metallurgical grade coal for Iron making. Subsequently, in 1976, WB was made a division of Tata Steel. The business objective of WB Division is to produce clean coal at optimum cost for captive use in the steel plant of Tatasteel at Jamshedpur. The strategy is to reduce ash with minimum loss of yield so that quality of coal improves and the cost is beneficial Vis-a Vis imported coal. The primary product of WB is the metallurgical grade coal for coke ovens, which converts coal into coke for use in the Blast Furnaces. The coal after mining is washed in the washeries to lower down the ash content from an average of 36% to 17%. This is a highly commendable achievement especially in view of the fact that Indian coal comes under the category of "difficult to wash coal". At present, the division operates 4 open cast coal mines viz., Quarry A, C ,D & SEB and two coal Washeries to produce about 4 MTPA of coking coal at 17% ash for the steel plant.

Like other conventional coking coal washeries across the world, West Bokaro coal washeries are designed to deslime raw coal at 0.5mm; the oversize (+0.5mm) is beneficiated in dense media cyclones (DMC) while the undersize (-0.5mm) is beneficiated in froth flotation (FF) via mechanical type flotation cells as shown in Figure 1.

Materials and methods

Typically, ~20% of the raw coal feed reports to the flotation circuit. In an audit carried out by M/s SGS in Sep'2015 for the flotation circuit, it was found that there is a scope for yield improvement in the fines circuit by ~3–4% on raw coal basis w.r.t to the maximum theoretical flotability as shown in Figure 2. Also, the performance of 0.5mm–0.25mm in flotation was the poorest of the lot as shown in Figure 3 wherein 60% of the material was reporting to the tailings.

Flotation is a complex three-phase process that is controlled by factors which can be divided into three facets: coal, chemistry and machine. Factors within the coal and chemistry areas are dynamic and hence, need to be dealt with by personnel on an ongoing basis in normal plant operations. However, factors associated with the machine are generally a characteristic of the machine type itself as this relates to the fundamental design of the technology. One of the most important characteristics of any flotation technology is air bubble generation and the size of air bubbles produced as this controls flotation kinetics and also, it dictates the car-

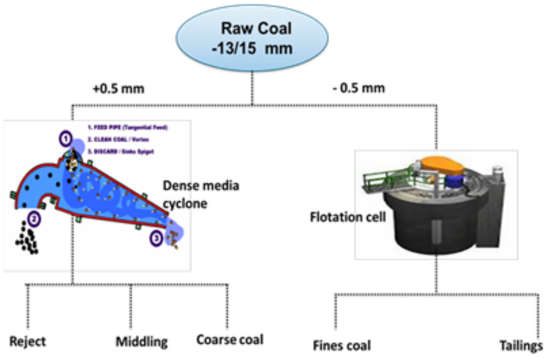

Fig. 1. West Bokaro coal washeries flowsheet
Rys. 1. Schemat zakładu wzbogacania węgla West Bokaro

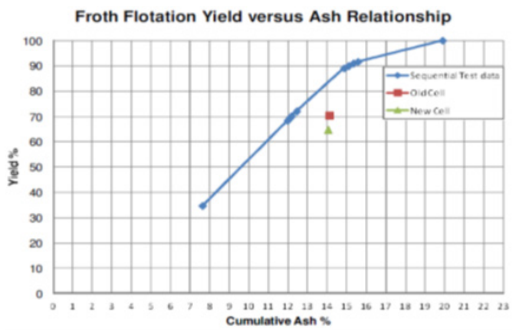

Fig. 2. Sequential evaluation vs. actual plant performance
Rys. 2. Ocena sekwencyjna a rzeczywista wydajność instalacji

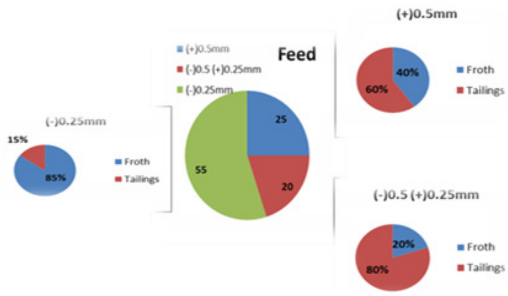

Fig. 3. Size wise recovery in FF cells
Rys. 3. Odzysk w komorach FF

Tab. 1. Comparison between mechanical, Column & Jameson cells
Tab. 1. Porównanie maszyn flotacyjnych mechanicznych, kolumnowych i Jamesona

Component	Jameson	Column	Mechanical
Bubble size	0.3-0.7mm	2-3mm	1-2mm
Carrying capacity	High	Low	Low
Equipment	Single cells	Single cells	Installed in banks
Footprint	Low	Generally sit outside plants due to large heights (10-17m)	Requires large footprint
Power component	Feed pump	Feed pump, recirculating pump and air compressors	Feed pump, agitators, rotors and blowers.
Maintenance cost	Low	Medium	High

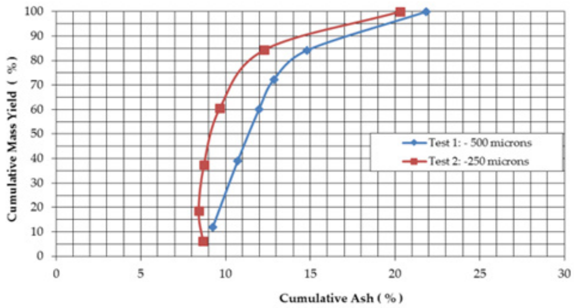

Fig. 4. Jameson testwork results
Rys. 4. Wyniki badań w maszynie flotacyjnej Jamesona

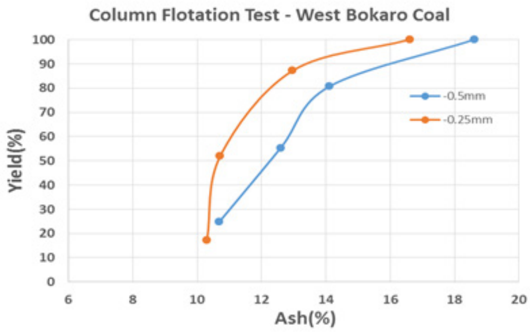

Fig. 5. Column testwork results
Rys. 5. Wyniki badań w maszynie kolumnowej

rying capacity of the machine. Another crucial component is how the machine effects collision and contact between air bubbles and particles. Apart from mechanical type flotation cells, the most popular flotation technologies elsewhere are Jameson & Column flotation and a brief comparison between them is shown in Table 1.

Results and discussion

Jameson cell

~20 kgs of fine raw coal (-0.5mm) sample of VIIISE seam was sent to M/s Glencore Technology (Australia) for testwork in Jameson cells. Two tests were carried out using the West Bokaro CHPP flotation feed sample. The first test was done on the -500 microns feed (which is the same as the current CHPP flotation feed). In order to understand the effect of feed size on flotation performance, for the second test, feed was screened at 250 microns. The results are shown in Figure 4.

Observations: High mass yield (over 80%) could be achieved at a concentrate ash less than 14% for the -500 microns sample. For the flotation feed of -250 microns, very high mass yield (over 90%) could be achieved at a concentrate ash less than 14%.

Column cell

~25 kgs each of -0.5mm & -0.25mm of VIIISE seam was tested in Column cell at Tatasteel R&D. Optimization studies couldn't be carried out due to less quantity of coal sample. The different stages of the testwork and results are shown in Figure 5.Yield of ~80% & 92% could be achieved at a concentrate ash of 14% for the -500 & -250 microns sample, respectively.

Comparison b/w mechanical-column & Jameson cells at 14% product ash

At 14% froth ash & normalized flotation feed ash, Jameson cell is capable of producing ~13.5% more than the mechanical cell and ~7.5% more than column cell i.e. an improvement of ~2.5% on raw coal basis having a potential benefit of ~25 crores per annum.For -0.25mm, Jameson cell is capable of producing ~7% more than the mechanical cell and ~4% more than column cell i.e. an improvement of ~0.7% on raw coal basis having a potential benefit of ~7 crores per annum.

Conclusions & way forward

It is evident that machine characteristics play a significant role in the beneficiation of fine coal. Test works carried out on lab scale indicate that Jameson & Column cells are capable of giving higher yields at the same product ash compared to the mechanical flotation cells for both -0.5mm & -0.25mm size fraction of coal. However, in actual conditions, due to the inefficiency of desliming screens, a significant amount of oversize material i.e. +0.5mm report to the flotation feed. Response of such oversize material is believed to be better in mechanical flotation cells compared to Column & Jameson cells. Keeping the considerations in mind, it has been decided to carry out a detailed feasibility study of installing a superior flotation technology for -0.25mm size fraction of coal at Tata Steel coal washery in place of -0.5mm.

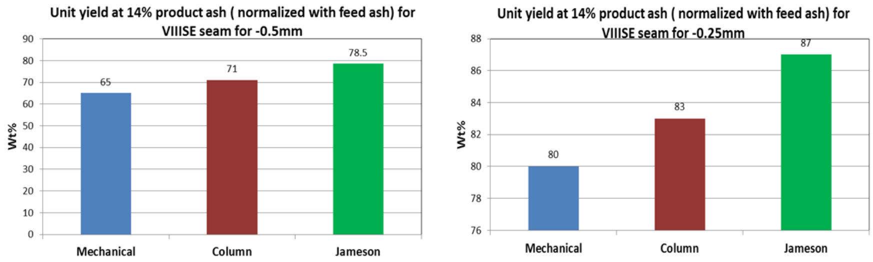

Fig. 6. Comparison b/w mechanical-column-Jameson cell for -0.5mm & -0.25mm

Rys. 6. Porównanie wyników wzbogacania w maszynie flotacyjnej mechanicznej i Jamesona dla klas ziarnowych -0,5 mm i -0,25 mm

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Literatura – References

1. “Busting the myths of flotation in the Australian coal industry” by L Huynh, I Kohli, D G Osborne, Xstrata Technology.
2. “Design and performance aspects of coal flotation – experiences with the Jameson cell” by L. Huynh, I. Kohli and D. Osborne, Xstrata Technology, Australia.
3. “Jameson cell scale-up experiences at BHP coal’s Goonyella coal preparation plant “by Michael F Carretta, (Process Engineer), James N Graham (Process Engineer), BHP Coal Pty Ltd.
4. Amelunxen, R.L and Redfearn, M.A., 1985. "The Mechanics of Operation of Column Flotation Machines", Proc. 17th Annual Meeting of The Canadian Mineral Processors. CIM, Ottawa, Canada, January, 13-31.
5. Espinosa, RG., Yianatos, J.B., Finch, J.A., and Johnson, N.W., 1988c. "Carrying Capacity Limitations in Flotation Columns", in Column Flotation '88 (K.V.S. Sastri, ed.), SME Annual Meeting, Phoenix, Arizona, U.S.A., January, 143-148.

Wpływ doboru maszyny flotacyjnej na wyniki wzbogacalności drobnego węgla (-0,5 mm i -0,25 mm) – studium przypadku Tatasteel

Zakłady wzbogacania Tatasteel w West Bokaro są przeznaczone do przeróbki klasy ziarnowej +0,5 mm w cyklonach z cieczą ciężką i klasy ziarnowej -0,5 mm w mechanicznych maszynach flotacyjnych. Zazwyczaj ~20% surowego węgla podaje się do flotacji. W wyniku szeregu badań układu wzbogacania miału węglowego ustalono, że istnieje możliwość poprawy wydajności wzbogacania miału o ~3–4% w przeliczeniu na surowy węgiel. Flotacja jest złożonym procesem który zależy od szeregu czynników , które można podzielić na trzy grupy: charakterystykę węgla, zjawiska fizykochemiczne i charakterystykę maszyny. Czynniki w obszarze są dynamiczne i dlatego obsługa procesu musi na bieżąco je kontrolować podczas normalnej pracy zakładu. Jedną z najważniejszych cech technologii flotacji jest generowanie pęcherzyków powietrza i wielkość wytwarzanych pęcherzyków powietrza, ponieważ wpływa to na kinetykę flotacji, a także decyduje o wydajności maszyny. Kolejnym istotnym elementem jest wpływ kontaktu pęcherzyków powietrza z cząsteczkami w maszynie flotacyjnej. Oprócz mechanicznych komór flotacyjnych, najpopularniejszymi technologiami flotacji są maszyny flotacyjne Jamesona i kolumnowe. Maszyny flotacyjne Jamesona mają przewagę nad kolumnowymi i mechanicznymi komorami flotacyjnymi pod względem lepszej kinetyki flotacji, małych gabarytów, niższych kosztów eksploatacji i konserwacji. W niniejszym artykule autorzy pokazali wyniki flotacji węgla West Bokaro w konwencjonalnych mechanicznych i kolumnowych maszynach flotacyjnych w Tatasteel R&D. Badania w komorach flotacyjnych Jamesona przeprowadzono na University of Queensland (Australia) dla węgla o uziarnieniu - 0,5 mm i - 0,25 mm. Wyniki dla klasy ziarnowej o wielkości -0,5 mm pokazują, że w komorze Jamesona uzysk wynosi 78,5%, w maszynie kolumnowej ~71% w porównaniu do 65% w maszynie mechanicznej. Wyniki dla klasy ziarnowej - 0,25 mm pokazują, że w komorach Jamesona otrzymuje się uzysk 87%, w maszynie kolumnowej ~83% w porównaniu do 80% w maszynie mechanicznej. Z przeprowadzonych testów wynika, że maszyny Jamesona są w stanie dawać wyższe wydajności przy tej samej zawartości popiołu w produkcie. Na tej samej podstawie zaproponowano instalację maszyn flotacyjnych Jamesona w skali pilotażowej w celu potwierdzenia wyników badań laboratoryjnych.

Słowa kluczowe: maszyny flotacyjne mechaniczne, maszyny flotacyjne kolumnowe, maszyny flotacyjne Jamesona, uzysk