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A comparative classification efficiency of hydro cyclone and high frequency screen – an experimental study

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Abstract. In coal preparation plants, classifying cyclones are commonly used to generate the pre-classified feed to the Reflux Classifier (RC) from coal fines. However, the efficiency of classification cyclones is low and generates a high amount of fines in the RC feed resulting in poor product quality. To address this issue, high frequency (HF) screen was explored as an alternative to classifying cyclone to generate desired RC feed. In the HF wet screening experimentation, the effect of four critical operational parameters such as feed rate, feed density, spray water and aperture size on the classification efficiency was investigated comprehensively. The overall screening efficiency of HF screen is in the range of 89-98%. HF wet screen generates lesser average percentage of fines (<250µm) at approximately 10% compared to 30% for the classifying cyclone. The classifying cyclone performance curve was modelled using modified Plitt's equation and imperfection in the range of 0.3 – 0.5. The corrected cut size (d_50c) of the classifying cyclone was in the range of 130 -180µm in comparison to ~250 µm for HF wet screen. The best operating conditions observed were at the aperture size of 230 µm, feed rate of 236 TPH, feed solids concentration of 12.1% with the spray water of 45 m ^{3}/hr.

1 Introduction

In mineral and coal processing plants, pre-classified feed is a pre-requisite for any concentrator to obtain maximum separation efficiency [1-4]. In coal preparation plant, the product quality of the Reflux Classifier™ (RC) was found to decrease when the feed contains a higher concentration of fines, and this can be attributed to the well-documented phenomenon of 'hydraulic entrainment'[4, 5]. The inefficient classification of the feed material hinders the utilization of the RC to their fullest extent, as is the case with many enhanced gravity separators[6, 7]. Therefore, selecting the appropriate classification equipment is of utmost importance to achieve maximum separation efficiency in concentrators.

Hydrocyclone is one of the mostly used classification equipment in many mineral and coal processing plants. The absence of moving parts, low manufacturing cost, simple maintenance and higher processing capability within a limited footprint make the equipment particularly attractive for mineral processing plants. Moreover, hydrocyclone can effectively manage varying flow rates while maintaining a low capital cost [8, 9]. The drawbacks of hydrocyclone are generation of high bypass, inadequate sharpness, substantial energy loss, and increasing circulating loads [8, 10]. The traditional method of cyclone classification, with its tendency to misplace higher ultrafine high-ash materials, can have a highly negative impact on the overall quality of the end product [4]. Screening is another classification method, and it has been utilized for over six decades to segregate solid particulate feed into distinct size categories. However, it was initially limited for scalping and the classification of larger-sized materials. Although wet screens have traditionally been employed for fine screening, there are still various challenges that have continued since their initial introduction. These challenges include low capacity, high panel wear rate, blinding issues, and the need for large installation spaces to meet capacity requirements[11]. Recently, there has been a renewed focus on the application of screens specifically for fine classification duties, potentially replacing hydrocyclones in closed milling circuits or serving as key components in hybrid classification circuits. The economic benefits of utilizing screen enhancements include increased production rates and decreased energy consumption as a result of lower recirculation loads.

The aim of this research work is to assess the classification efficiency of hydrocyclone and HF fine screen to produce suitable feed to the RC in coal preparation plant. Experimental study conducted at a full-scale HF fine screening system to analyse the impact of four crucial operational factors, namely aperture size, feed rate, feed solids concentration and spray water on the classification efficiency. The classification efficiency of the existing hydrocyclone were obtained by conducting a sample campaign and the results were compared with screens.

2 Literature Review

Screening is a separation process that classifies materials according to their particle size and it is a critical unit for mineral and coal processing. For gravity-based separation processes, the size of particles can affect the efficiency. Based on the particle sizes that need to be classified many different types of screens are commonly used in the mineral processing applications. Usually, in mineral processing applications, Grizzly screens are used for rough screening of coarse particles (50mm to 300mm). Trommels are another type of screen that utilize a cylindrical rotating design separator for particles from 100 mm to 4mm[12]. With the rise in need for screening fine materials, complex screen designs like the pansep screen flip-flow screens were introduced in the mineral processing circuit. Flip flow screen employs unique screen panels that have stretched and relaxed sections that will allow for higher generation of G force and separation of damp materials (up to 0.5mm). Pansep screens are also used in finer particle separation for cut sizes from 0.045 mm to 0.6 mm [13].

Screening applications in mineral processing can also be classified as dry and wet screening, depending on the presence or absence of water in the screening process. Conventional screening systems used to screen coarser particles or low moisture particles are usually dry screens. Dry screening is generally used for particle sizes greater than 5 mm. Particles below 5mm down to 45µm are characterised as fine particles and are generally separated using wet screening process [10, 13, 14]. Wet screening is normally accomplished with high frequency, low amplitude, vibrating screens with either elliptical or linear motion (the circulating and revolving screen) [11, 15]. HF fine wet screens are reported to offer a higher circuit capacity and a more closely distributed product size distribution [16]. The HF fine screen has also been identified as capable of classifying the ultrafine (75µm) coal particles to create the necessary feed (75x100 µm) for the Falcon concentrator [17]. Recent technological developments in the area of fine wet screening involved the improvement in design to overcome the limitations of the conventional screens like blinding during screening of fine particles. The HF fine screen's capability to produce sharper separation, has been reported to enhance the capacity of the closed grinding circuit. The multi deck high frequency wet screen (Stack sizer) in the closed circuit grinding was reported to reduce the presence of particles less than 75 microns resulting in the improvement [18].

The performance of a screen can be evaluated through two metrics: screening efficiency and imperfection factor. Despite the abundance of literature on the efficiency metric on screen, comparative analysis of screen is hindered by the variation on the particle size ranges the screens operate. The literature reports screen efficiency for different types of screens. The reported screening varied from 6 mm to 0.15 mm. Chen et al. analysed the screening efficiency of trommel screen for coal particles at 4 mm size and found that the screening efficiency can reach up to 90% [12] . When employing the flip-flow screen, Chen et al. successfully separated coal particles of size 3 mm and 6 mm from a feed size of less than 100 mm, reporting screening efficiencies of 82.51% and 85.29%, respectively [19]. The comparative analysis of the performance between the vibrating flip flow screen and the circular vibrating screen was conducted using a screen designed for 3 mm particles by Yu et. al. The experimental results indicated that the vibrating flip flow screen exhibited a higher screening efficiency of 77.62%, in contrast to the circular vibrating screen, which achieved a screening efficiency of 61.99%.[20]. Banana screen with varying inclination was used to separate the coal particles of 6mm from the feed size of 50mm and the separation efficiency reaching up to 93% was reported[21]. Mohanty et al. analysed the performance of pansep screens for fine particle separation (150 microns) at lab scale and plant scale and found that pansep screens give near ideal separation. At pilot scale, the separation efficiency of 98% which is near ideal separation was observed for pansep screen and during plant trial, the separation value of around 90% was observed [22, 23]. Imperfection factor is another efficiency metric that indicates how sharply the screen separates the particles. Mohanty et al. in 2002 measured the imperfection factor for coal particles at 150 microns to be around 0.18 [4]. For the Pansep screen in plant testing the average value of imperfection was 0.14 [22]. Recently, Akbari et al measured the imperfection factor for -1mm and -2mm and the imperfection factor for the two cut sizes were 0.15 and 0.11 respectively[24].

3 Experimentation

3.1 Coal characterization

In the experimentation, the coal sample was collected from the feed to Jamadoba coal preparation plant, India. The proximate analysis of the coal was carried out by following the American Society for Testing Materials (ASTM) standard procedures using a thermogravimetric analyser (TGA 701) supplied by Leco. The ultimate analysis was carried out by following the ASTM standard procedures using a Leco 628 CHN/S elemental analyser. The chemical analysis (proximate and ultimate) results are shown in Table.1. The size wise ash analysis is also shown in Fig .1. The true density of the coal sample was determined using the helium pycnometer.

Table 1. (a) Proximate and ultimate analysis and (b)chemical analysis of coal

S No.	Parameter	Wt, %	Element	Wt, %
1	Ash	28	Carbon	63.2
2	VM	21	Hydrogen	3.7
3	Moisture	1.4	Nitrogen	1.3
4	FC	49.5	Sulphur	0.9
5			Oxygen	2.9

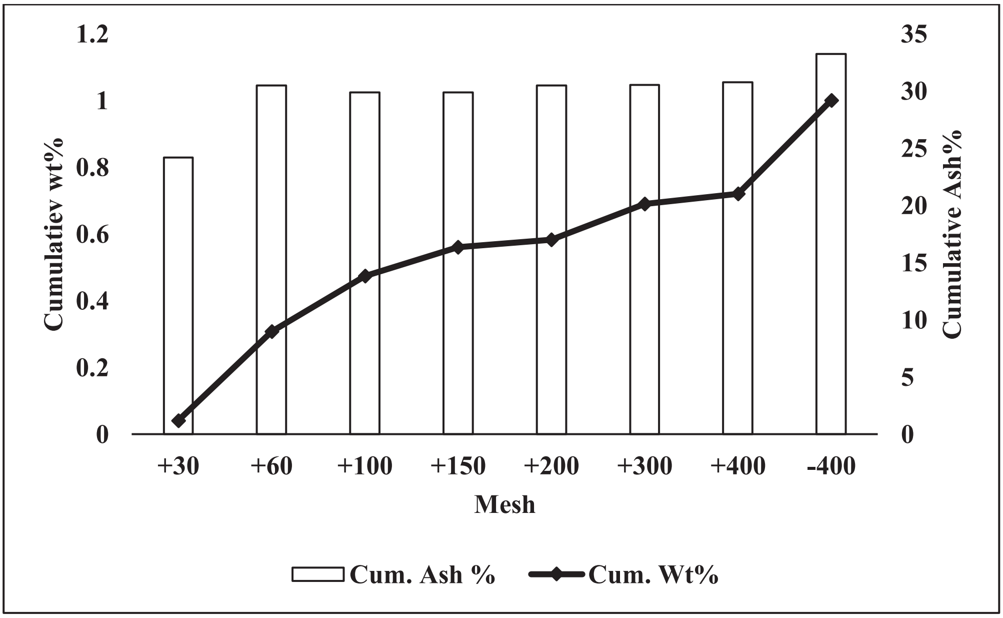

Fig.1.Size wise ash analysis of coal sample

3.2 Classifying cyclone partition curves

In coal washery, the classifying cyclone is being used as classifying unit to generate feed to the Reflux Classifier. The feed size to the hydrocyclones is less than 0.5mm and expected to produce greater than 250µm particles in the underflow and less than 250µm particles in the overflow. The specification of the classifying cyclone is shown in Table 2. The cyclone at the plant is having diameter of 650 mm. The cyclone was designed to operate at an inlet pressure of 45 kPa and the designed feed solid concentration of 8.5% by weight. The classification curve for the hydrocyclones can be generated experimentally by collecting the coal samples from the feed, oversize, and undersize flows. By analysing the particle size distribution of each sample or considering the material mass flow in each stream, the efficiency curve can be generated[25]. There are two performance measures, one is cut size (d50) and Imperfection (I). Cut size is defined as the size for which 50% of particles in the feed report to the underflow. The imperfection values indicate the degree of deviation from the perfect separation. The imperfection of the gravity separation can be represented by

$$I = \frac{d_{75} - d_{25}}{2d_{50}}$$

Where,
d_{75} – 75% of feed particles report to underflow
d_{25} - 25% of feed particles report to underflow

Table 2. Hydrocyclone specifications

S. No	Parameter	Value
1	Cyclone diameter, mm	650
2	Inlet diameter, mm	211
3	Vortex Finder diameter, mm	320
4	Spigot diameter, mm	130
5	Angle of inclination, O	75
6	Operating pressure range, kPa	45

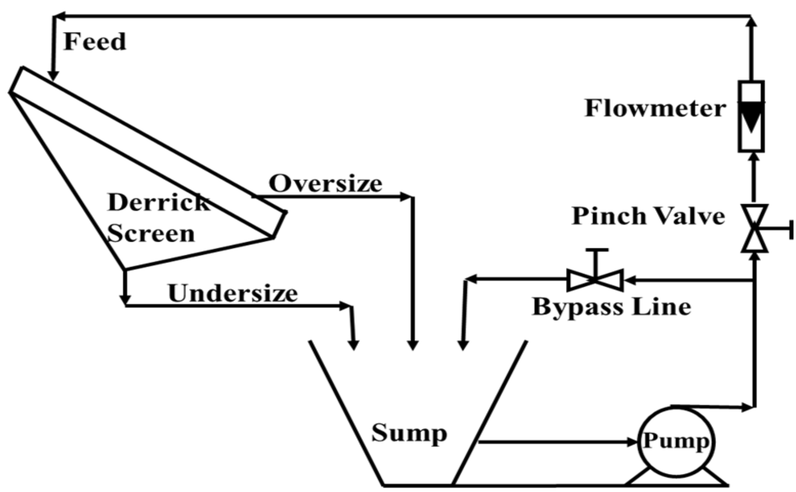

Fig.2. Schematic diagram of HF screen experimental setup

Table 3. HF fine screen single deck specifications

S. No	Parameter	Value
1	Screen Length, L	2591 mm
2	Screen Width, W	1876 mm
3	Inclination	22.5 deg
4	Motor Speed	1200 rpm
5	Screen open area	32%
6	Motor Power	2*3.6 kw

3.3 High frequency fine screening experiments

Full scale screening experiments were carried out using a single SuperStack® sizer. The experimental rig consists of a centrifugal pump, sump and superstack with flow meter and the process flow sheet of the experimental rig is shown in Fig.2. To initiate the examination, the sump is filled with water and the pump is started. A portion of the coal sample is then transferred to the sump, ensuring that it is thoroughly mixed to achieve the desired pulp density through recycling. A sample of the feed slurry is then taken to determine the pulp density. The volumetric flow rate is measured using a magnetic flow meter and adjusted by manipulating the pinch valves on the screen feed and bypass lines and the screen details are shown in Table 3. For each set of test conditions, the oversize and undersize streams, as well as the feed stream are sampled at steady state. The experimental study involved conducting a mass balance analysis, which was then utilized to determine the screening efficiency, a parameter that can be analogous to recovery in any concentrator. The screening efficiency can be affected by various parameters that can be classified into three groups: 1) design parameters: angle of inclination, aperture size, screen open area, intensity of vibration, screen length and width. 2) operating parameters: feed rate, feed density, pulp density, spray water, feed box design and selection. 3) material characteristics: particle size distribution (PSD), particle shape, bulk density, specific gravity, moisture, and angle of repose. Since the design parameters and minerology is not a controllable parameter, so in the current research work, the effect of four critical operating parameters such as feed density, feed rate, spray water and aperture size were considered for the experimental conditions. The critical parameters of the HF fine screen and their levels are shown in Table.4.

Many variables affect the performance of a vibrating screen, such as: screen cloth (shape and size of the apertures), amplitude and frequency of vibration, screen angle, density, shape and size of the particles to be screened, viscosity of the suspension and feed rate and the effect of various operational parameters on the efficiency of screening was investigated [26-28]. For coarser particle screening separation efficiency increased by using the short stroke and high frequency vibrating screens. Whereas, for the fine particle, better screening efficiency was achieved using longer stroke and slower speed with circular motion (DeCenso 2000).

Table 4. Operating parameters of HF wet screening experiments

S. No	Parameter	Range
1	Aperture size, µm	230 & 250
2	Feed flow rate, TPH	236 & 463
3	Feed Pulp Density, %	8,12 & 25
4	Spray water, m3/h	0 and 45

3.4 Calculation of screening efficiency

In the screening process, a machine is utilized to divide a feed stream into oversize and undersize products. The particles that are smaller than the aperture size pass through the aperture and are collected in the undersize collecting chamber, while particles larger than the aperture travel the entire length of the screen and are discharged into the oversize collecting chamber. The efficiency of the fine wet screening process is determined by calculating the correct placement of material, often expressed as a percentage. Three efficiency values can be calculated: oversize efficiency, undersize efficiency, and overall efficiency. These values are calculated based on the particle size distribution of the feed and products. The following formulae are used to calculate weight splits and efficiency of screen.

A - percent of oversize in the feed.
B - percent of undersize in the feed (100 - A).
C - percent of oversize (coarse) in the oversize product.
D - percent of undersize (fines) in the undersize product.

The weight splits and efficiency values are calculated as follows.

$$Undersize\ weight\%, U = \frac{100(C-A)}{C+D-100} \tag{1}$$
$$Oversize\ weight\%, O = 100 - U \tag{2}$$
$$Undersize\ efficiency, E_u = \frac{U*D}{B} \tag{3}$$
$$Oversize\ efficiency, E_o = \frac{O*C}{A} \tag{4}$$
$$Overall\ efficiency, E = \frac{U*D+O*C}{100} \tag{5}$$

The targeted feed to the Reflux Classifier is greater than 250μm, so the efficiency of screen is evaluated using the oversize efficiency along with the overall efficiency. Since, RC performance deteriorates with the presence of fines (<250μm) in the feed. Therefore, the evaluation of the optimal performance of the HF fine wet screening operation considers the oversize material, overall efficiency, and the proportion of fines within the oversize material.

4 Results and discussion

4.1 Coal characterization

The size analysis results are shown in Fig. 1. and it is evident that the ash is distributed uniformly across all sizes. The ash content of the dried feed was 28% and the average particle size (d_{50}) was greater than 500 μm. Proximate analysis shows that, the sample was found to contain 1.4% moisture, 21% volatile matter and 50% fixed carbon. The true density of the sample was measured to be around 1.694 g/cc.

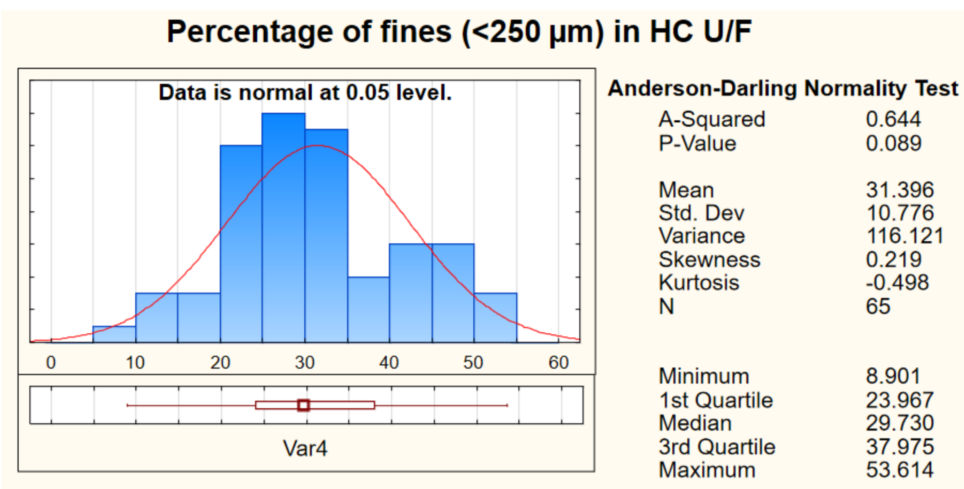

Fig. 3. Percentage of fines (<250μm) in the classifying cyclone underflow

4.2 Percentage of fines in classifying cyclone underflow

To assess the fines percentage (<250μm) in the RC feed, a sample campaign was conducted for the classifying cyclone underflow (i.e., the feed to RC), and the results are illustrated in

Fig.3. The sample campaign results demonstrated that the size distribution followed a normal distribution. The average fines content in the RC feed was approximately 31%, with minimum and maximum percentages of fines being 9% and 53% respectively. A higher fines percentage in the RC feed suggests a greater likelihood of the fines being carried over to the clean coal through hydraulic entrainment. These fines typically contain higher ash content, which can degrade the product grade. Furthermore, coarse particles (>1mm) are sometimes present in the RC feed, and these can form a thick layer on the oversize protection screens inside the RC. The oversize protection screens, with an aperture of approximately 6mm, serve to prevent larger particles from clogging the fluidization nozzles in the Reflux Classifier. However, if a layer of particles accumulates on these screens, it can obstruct the flow of feed slurry to the fluidization section, leading to short-circuiting and reduced separation efficiency. This mandates the cleaning of the oversize protection screen during the maintenance cycle to ensure proper functioning of the RC. Therefore, exploring alternative technologies beyond the current classifying cyclone is imperative.

4.3 Classifying cyclone performance curve

The partition curve commonly exhibits an 'S'-shaped sigmoidal curve, with the point of intersection with the y-axis denoted as Rf. Rf represents the fractional amount of the feed flow bypassing to the underflow. As the finest particles possess insignificant mass, they simply follow the liquid and tend to split in the same proportion as the fluid. Therefore, reduced partition curves are employed to determine the adjusted cut size d_{50c}.

For the sample with the lowest imperfection factor, analysis of the samples collected during the sample campaign revealed that the cut size (d_{50}) was about 120 µm. The cut size of the classification cyclone was found to vary between 120 and 180 µm, although the intended design target was 250 µm. Correcting for the bypass using the Rf resulted in obtaining the corrected cut size (d_{50c}) of 140 µm. For the classifying cyclone results are shown in Table.5, the measured imperfection factor around 0.3-0.7. A value approaching zero signifies an ideal separation, whereas an increase in value results in a decline in classification efficiency. The performance of any classifier can be classified as excellent and good if the imperfection factor (I) less the 0.02 and 0.2- 0.3 respectively. The imperfection factor more than 0.6, then the classifier as a bad separator [29].

Table 5. Classification Cyclone Results summary

	D50	D50C	D75	D25	I
Test No -1	120	140	175	95	0.29
Test No -2	110	130	190	90	0.38
Test No -3	160	180	300	120	0.50

4.4 HF fine screening results

When assessing the performance of a screen, two parameters are commonly utilized: capacity and efficiency. Capacity denotes the volume of material that is introduced to the screen per unit time and per unit area of the screen surface [14]. However, these parameters are at odds with each other, with an increase in screen capacity resulting in a decrease in efficiency, and vice versa [30]. As illustrated earlier there are three common efficiencies: overall, oversize, and undersize efficiency have been used to evaluate the screen efficiency. Even though three efficiencies are important, keeping the objective in mind the oversize efficiency is very crucial in obtaining the best performance. To prevent an increase in the coal ash content of the product, it is crucial that no fines (<250 µm) are allowed to enter the Reflux Classifier feed. If these fine particles are present, they will be carried along with the product through entrainment, leading to undesirable outcomes. Hence, along with the oversize efficiency, the amount of fines (<250 µm) reporting to the oversize is also very important.

4.5 Effect of aperture size

The aperture size plays a crucial role in determining the capacity as well as the efficiency of the screen [13]. A change in aperture size often affects the screen open area, which is defined as the total area of apertures available for passage of fine particles through the screen surface. Screening experiments were conducted at a throughput of 66 TPH with a solids concentration of 19.5 to examine the impact of aperture size. Two different aperture sizes, namely 230 µm and 250 µm, were tested, and the outcomes are illustrated in Fig. 4. From the experimental results it was observed that the oversize and overall efficiencies reduced marginally with increase in aperture sizes. The trend remained consistent regardless of the presence or absence of spray water. Tsakalakis studied the effect of aperture sizes on screening efficiency and measured the undersize recovery. It was reported that undersize recovery was reduced with the decrease in aperture size from 4 to 0.6mm [31]. During the current investigation, it has come to light that the observed results contradict the findings previously published. This discrepancy can be attributed to the narrow range of aperture sizes, which ultimately leads to a lack of significant impact on screen efficiency.

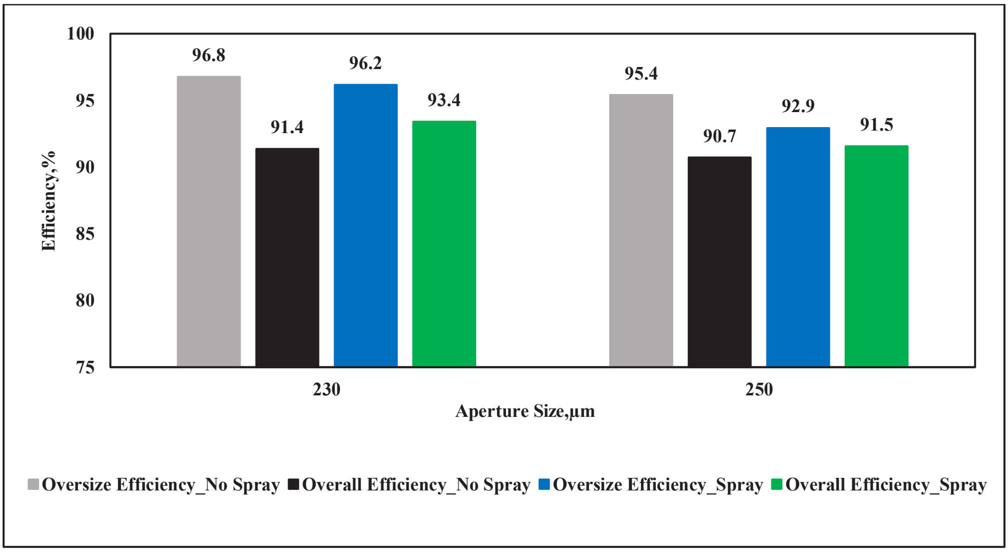

Fig. 4. Effect of aperture size on screening efficiency

The fines content remains relatively unchanged as the aperture size increases, regardless of the presence or absence of spray. Fines were found to be approximately 8% when spray water was applied, as opposed to a fines rate of 11% without the use of spray water. From the results, it was observed that a higher screening efficiency of 93.4% and a lower fines content (8%) were observed at an aperture size of 230 µm for a given feed particle size distribution. Therefore, a 230 µm aperture size was chosen for the subsequent parametric investigation to assess the screening efficiency.

4.5.1 Effect of feed rate

Feed flow rate is one of the most critical factors affecting the screen performance, both in terms of efficiency and capacity. Typically, feed rate is expressed as dry mass flow (t/h) per unit time unit area [32]. Usually, lower feed rates provide higher efficiency, but at the cost of reduced capacity, which is an undesirable condition for industrial operation. Higher feed rates with reduced efficiency due to higher flow rates provide more material to the screen and increase the rate of transport of material across the length. This results in the generation of a thicker particle bed over the screen surface which further reduces the screening efficiency. So, it is important to trade-off between the feed rate and efficiency. So, to investigate the effect of feed rate on screening efficiency, experiments were conducted at two different feed rates of 236 and 463 TPH, with and without spray water. The aperture size was kept constant at 230 µm and the results are shown in Fig. 5. From the results, it was observed that the efficiency of separating oversize particles improved, while the overall efficiency decreased as the feed rate was increased from 236 to 463 TPH, irrespective of the spray water utilization. As explained before, higher feed rates resulted in the formation of a thicker particle bed over screen surface and finer particles must percolate through this particle bed before they reach the screen surface. Hence, these finer particles do not get sufficient residence time and most often, get carried over to the oversize stream. This resulted in the decrease in screen efficiency. On a similar note, the fines content in the oversize fraction increased with an increase in the feed rate for the 230 µm aperture sizes, irrespective of the spray conditions. The observed experimental results matched with the previously published literature[28, 33]. Hence, it can be inferred that a lower feed rate is advised to achieve maximum efficiency while minimizing fines in the oversize fraction.

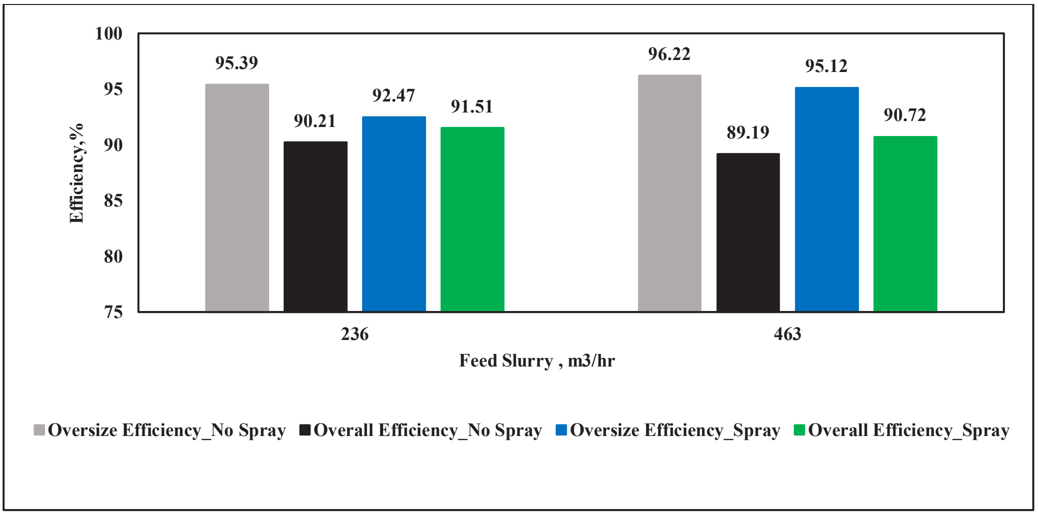

Fig. 5. Effect of feed rate on screen efficiency

4.5.2 Effect of feed solids concentration

The efficiency of the separation process in fine particle wet screening is influenced by the solids concentration in the feed [11]. Screening experiments were carried out to investigate the effect of pulp density of feed stream on screening efficiency for the aperture size of 230µm, both with and without spray water. The experiments were conducted at solid concentrations of 8.1, 11.9 and 26.1%. The results from the experiments are shown in Fig. 6.

From the results, it can be inferred that the oversize efficiency decreased marginally with increase in solids concentration from 8.1 to 11.9 % and increased marginally with the increase in solids concentration to 26.1%. The formation of a thicker bed on the screen deck due to the increase in the solid concentration in the feed can result in a decrease in the water content to the undersize. This could result in a large fraction of fine particles not reaching the screen aperture and getting carried over to oversize.

Initially, the overall efficiency increased with the increase in solids concentration, but reduced with a further rise in solids concentration, in the absence of spray water. On the other hand, when spray water was used, the overall screening efficiency reduced with increase in solids concentration .The observed results are in line with the published literature [16]. Coming to fines content in the oversize, the fines (<250 µm) content reduced with the initial increase in the feed solids concentration from 8.1 to 11.9% and increased with the increase in solids concentration to 26.1%, irrespective of the spray condition. From the results, it can be inferred that the maximum overall efficiency and lesser fines in the oversize fraction can be achieved at 12.1% solids concentration for a screen having aperture size of 230µm, irrespective of the spray condition.

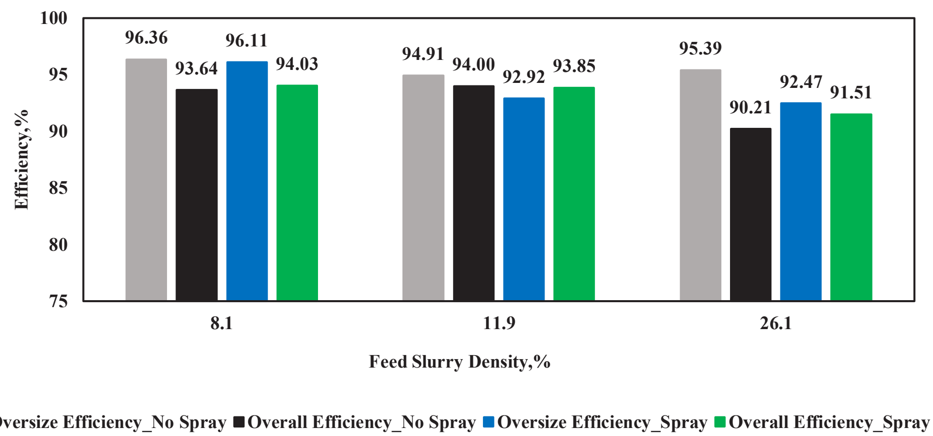

Fig 6. Effect of feed PD on screening efficiency

4.5.3 Effect of spray water

Generally, the feed is introduced at the feed point of the screen, a substantial amount of water in the feed quickly passes through the screen surface. This can result in an insufficient quantity of water available for the transportation of fines in the screening process along the screen length. This is usually overcome by using spray water along the length of the screen. The impact of the spray water on the screening efficiency can be understood from Figs 4, 5, and 6. The presence of spray water has resulted in a lesser amount of fines in the oversize compared to the case without spray water. This can be attributed to repulping of the feed material on the screen by the wash water resulting in the release of entrapped fine particles. The released fine particles will eventually reach the underflow screen through the screen opening resulting in the reduction of ultrafine bypass to the oversize product. From the results, it is quite evident that the presence of spray water can improve the screen efficiency and results in lesser amount of fines in the oversize. Hence, a spray water flow rate of $45m^3$/hr was recommended for the fine wet screening operation for a given throughput and aperture size. (Should we mention the through put range and aperture size or can it work for all sizes and throughput) mention experimental throughput ranges only where spray water flow rates required were different from the specified 45m^3/hr.

4.5.4 Percentage of fines in HF Screen O/S

A total of 26 fine wet screening experiments with high frequency (HF) screens were carried out to examine the impact of four crucial factors (aperture size, feed rate, feed solids concentration and spray water) on the screening efficiency. The descriptive statistical distribution for the percentage of fines (<250µm) in the screening oversize across all the experiments is shown in Fig. 7. The average value of fines reporting to oversize was 10% and with the minimum and maximum being 5 and 16.2% respectively. Compared to classification cyclone, the amount of fines in the oversize was substantially low for HF fine screen. Therefore, it can be concluded that HF fine screen has higher classification efficiency compared to classifying cyclone and the installation of the same in the RC circuit can improve the equipment's performance.

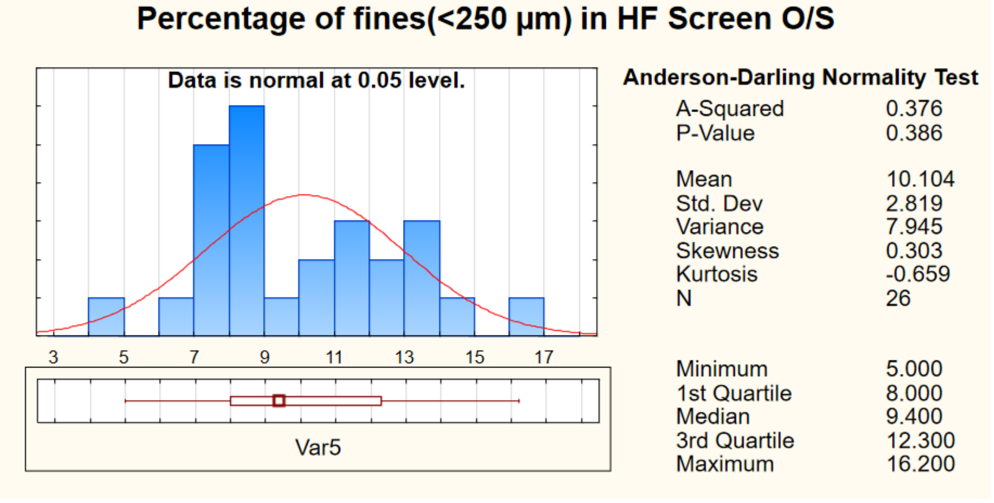

Fig. 7. Percentage of fines (<250µm) in the HF Screen oversize

5 Conclusions

In the current investigation, two types of classifiers namely hydrocyclones and HF fine screens were evaluated to produce suitable feed to the Reflux Classifier (RC). The performance criteria are to determine which classifier is able to generate less quantity of fines (<250 µm) to the RC from the feed of less than 500 µm. In coal washery, hydrocylones are used as classifiers to generate feed to RC and it was observed that these units resulted in around 30% of fines content in the RC feed through sample campaign. The hydrocyclones classification curve was modelled using modified Plitt's model with Kelsall function. A corrected cut size (d50C) 140 µm against the target size of 250 µm with the Imperfection factor (I) in the range of 0.3-0.5 was observed for the plant scale hydrocyclone. Full scale single deck screening experiments were carried out using HF fine screen and the effect of four critical operational parameters such as aperture size, feed rate, feed solids concentration and spray water was investigated comprehensively in the screening efficiency of fine screen. The fine screen able to generate around 8% of fines with screening efficiency of 85-95%. The best operating conditions observed was at the aperture size of 230 µm, feed rate of 236 TPH, feed solids concentration of 12.1% with the spray water of 45 m^3/hr. The observed cut size of the screening experiments was at 250 µm.

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