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Modular misplacement investigation journey at Bank 2 coal washing plant

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Abstract. Goedehoop North Plant experienced misplacement challenges that often came in the form of struggling to balance production and classification for ensuring the correct particle size distribution was being fed to the correct circuits. The philosophy that a trolley would often be used to push material to a smaller aperture banana screen often fed fine coal material to the wemco section leading to high misplacement values. The first step taken was to produce a feed distribution that would ensure the wemco bins were fed evenly by maintaining similar feed bin levels using a flopper. An improvement was observed on misplacement but showed further optimisation was needed. This was then further followed by changing the panel apertures on the wemco two banana screens from 16mm to 20mm aperture sizing for permanently eliminating fines fed to the wemco section and upgrading the DMS circuit feed from 550 tons per hour to 650 tons per hour by deconstraining a key conveyor belt. With the changes made, the used screen panels were set to a coarser aperture and kept the same for both screens which prevented the misplacement of fine coal into the WEMCO circuit and has significantly reduced the overall plant product coal misplaced to discard. This strategy used has seen the Plant running optimally by meeting the required rates and classifying feed to plant efficiently.

1 Introduction

The DMS processes ROM at a plant design head feed rate of 932 tph, producing an EXPORT Trade product that is stacked on the product stockpile. Coal from the ROM stockpiles report to four different active silos that are used for intermediate storage. From these silos, the ROM is screened using banana screens into 20mm (previously both 16mm and 20mm) prior to processing in the DMS plant. To control the feed rates reporting to the coarse and medium circuit and the duff bin level, a trolley is installed and connected to the APC to control the capacities going into the banana screens at a 50/50 feed split.

The oversize coal from the banana screens reports to the coarse coal circuit, where it is washed in two high gravity (HG) Wemco drums. The sinks from the HG drum are discarded and to minimize fines production in the floats product, a screen is used following a drain and rinse screen to remove the -50mm fraction, of which only the +50mm coal is fed to a LAC crusher for reduction to -50mm.

The undersize coal from the banana screens reports to the medium coal circuit and is wet screened to remove the -0.63mm fraction. The +0.63mm coal is then processed in four high gravity (HG) cyclones with a diameter of 800mm, producing EXPORT product. The HG

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cyclone underflow is discarded and the EXPORT product from the cyclones is dewatered in vibrating centrifuges prior to storage.

The -0.63mm coal from the DMS cyclone prep screens is beneficiated separately. The coal is first classified using 13 fine coal classification cyclones to remove the -150 micron high-ash fraction. The underflow from the classifying cyclones is then beneficiated using spiral classifiers. The spiral product is dewatered using dewatering screens with an aperture size of 0.63mm and is mixed with the EXPORT product.

The discard from the spirals is dewatered after being classified by a cyclone where the overflow reports to the thickeners and the dewatered underflow then goes to the MRF facility along with other plant discards. Hammer samplers are installed on both the product and discard conveyors to monitor plant quality and misplacement. The classifying cyclone overflow gravitates to two thickeners, where it is flocculated and pumped to the co-disposal facility.

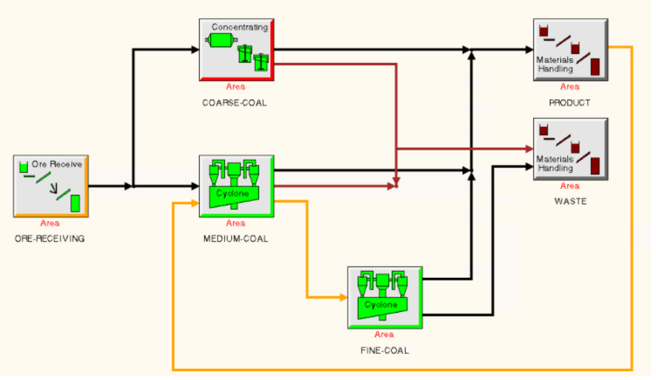

Fig. 1. Plant flow overview

2 Theory

Misplacement of product in sinks is often overlooked with many aiming just to be below the target number. When in essence optimization work has shown that with understanding of what is happening in the circuits may lead to lower misplacement values. This in return leads to proper recovery of coal product and increased saleable tons. Misplacement has often been measured through the sampling of a composite sample by doing float and sinks analysis with this being calculated back to FTP. The composite sample at Bank 2 Plant is a combination of a total of four circuits analysed in one sample. This has often presented challenges in investigating higher misplacement values as one cannot trace which circuit is misplacing. It was then decided from the investigation done that modular sampling needs to be done on the sinks screens to try and understand the source of the misplacement observed.

3 Problem Statement

Bank 2 Plant has a misplacement target value of 1.50% of FTP. The actual misplacement value is calculated from the composite sample taken from a hammer sampler that is taken to the laboratory for float and sinks analyses. This is done once a week and sample is taken to an external laboratory for the analyses on Tuesdays with a 1-week turnaround time. Observations made from the analyses was that the wemco drums were on target and that the DMS cyclones were misplacing coal as according to the size fraction observed on the analyses and misplaced. The graph in figure 2 shows the total plant misplacement from the period 2020 to 2025. There is a downward trend with the implementations done over the period and this is explained in the methodology and results. 2025 however comprises of only January and February.

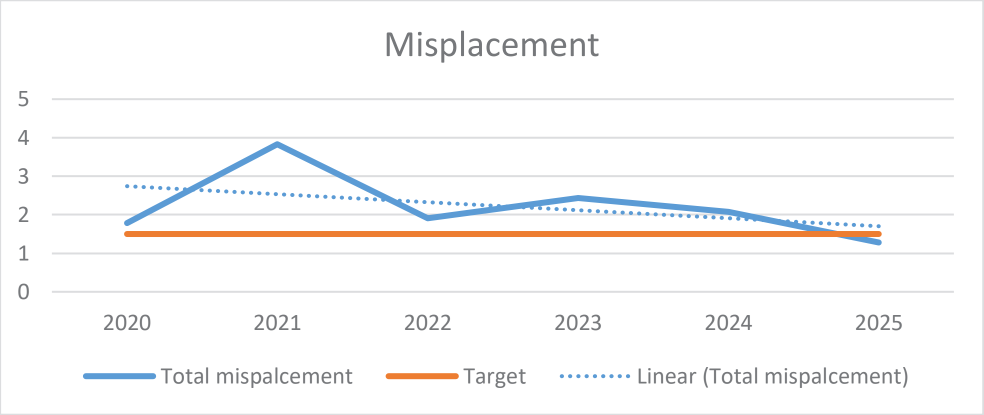

Fig. 2. Misplacement results 2020-2025

4 Literature

4.1 Dense medium separation

Dense medium separation (DMS) is one of the most effective and widely used method of coal cleaning. This is done on basis of density where a heavy liquid (magnetite medium) of a suitable density is used. The coal minerals lighter than the medium will float, while those denser than it sinks as shown in 3 below. Dense medium processes offer some advantages such as the ability to make sharp separations at any required relative density; a high degree of efficiency can be achieved even in the presence of high percentages near-density material; the separating density can be closely controlled; and a wide range of sizes can be treated with the use of different units (1).

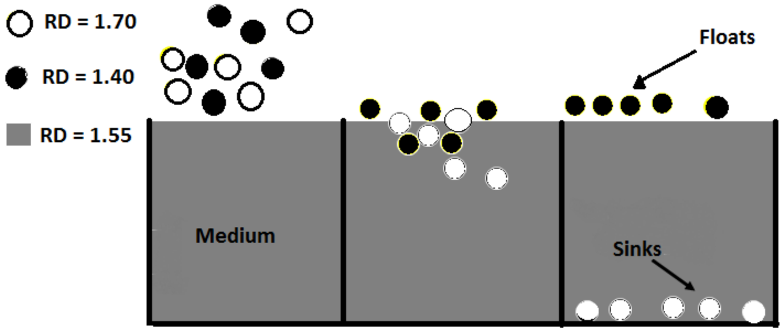

Fig. 3. Schematic illustration of dense medium separation.

4.2 Wemco drums

The Wemco drum separator consists of a cylindrical drum that rotates on bearings, inside is a shallow pool of medium at the density required to produce the clean coal of the specified quality. Separation is accomplished by the continuous flow of the lighter floating coal over the dense medium exiting the drum through the floats stream as the products. The heavier sinking material sinks to the bottom of the drum where it is continuously being removed by lifters installed inside the drum. The lifters have holes to allow medium to flow through and they empty into a sinks launder when it reaches the upper part of the drum. This then exits the drum as discard material (2). These drums are commonly used in the coal industry as they are simple, reliable and require relatively low maintenance.

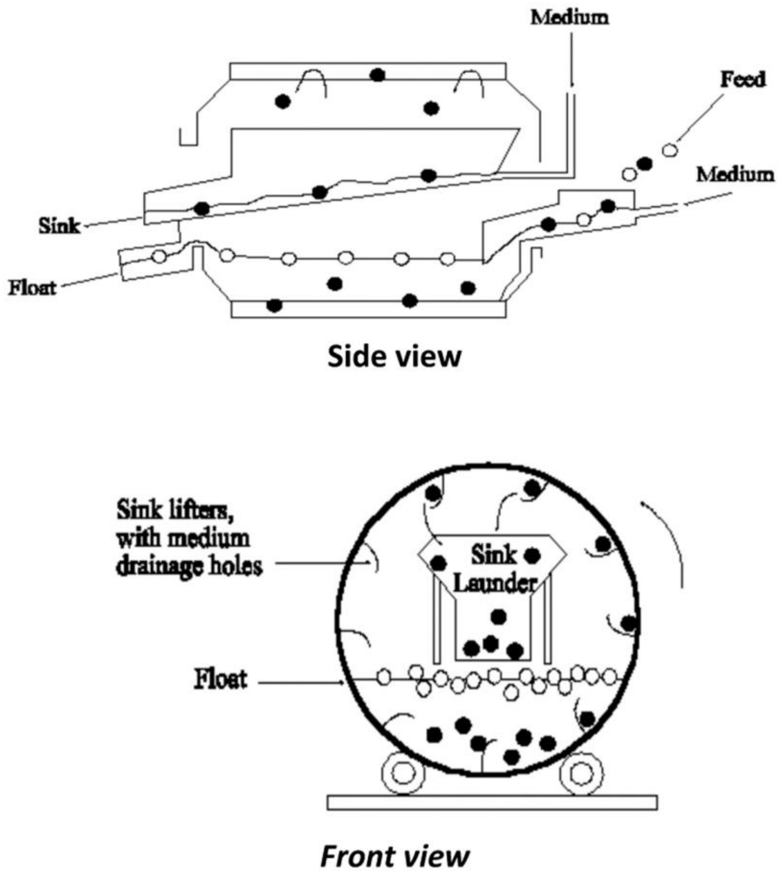

Fig. 4. Schematic representation of a Wemco drum's side and front view (1)

4.3 DMS cyclones

DMS cyclones use fluid pressure to create rotational fluid motion. The coal suspended in the medium is introduced tangentially to the cyclone producing a centrifugal force. Due to these forces, the heavier material tends to be pushed more towards the walls of the cyclone causing them to exit through the spigot as sinks. The lighter coal material on the other hand tends to rotate along the axis of the cyclone, exiting through the vortex finder as floats (2). This unit is also reliable, simple and offer relatively low maintenance since it has no moving parts.

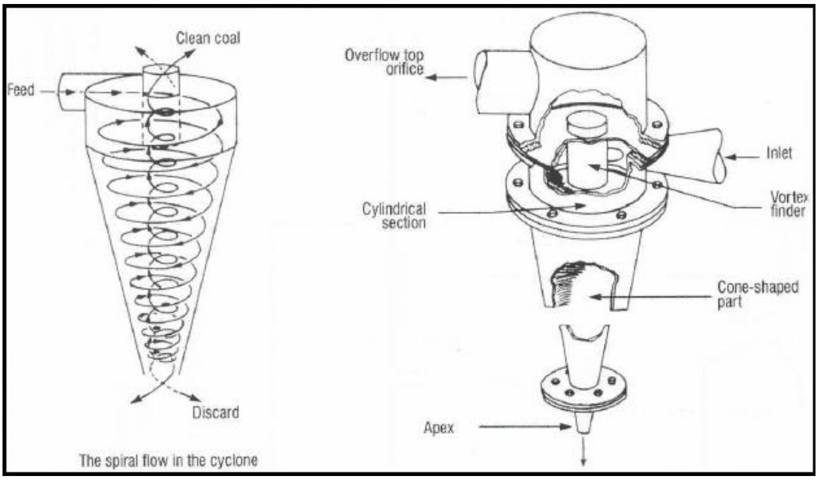

Fig. 5. Schematic representation of a cyclone (1)

5 Methodology

The investigation was then as a starting point to focus on sampling discard from each individual circuit for float and sinks analyses.

5.1 Creation of mask codes

The first step in doing the analyses was to create mask codes to be used by the laboratory for washability analyses. This includes the screening sizes to be used and the density intervals to be used. The sizes used for the different circuits are highlighted in table giving 3 different sized fractions.

Circuit	Upper screen size (mm)	Mid-screen size (mm)	Lower screen size (mm)
Wemco A	+16	-16	+6
Wemco B	+16	-16	+6
DMS	+16	-16	+0.5
Spiral		1	-0.5

Fig. 6. Discard sample size split

5.2 Sampling

Sampling was done on the sinks screen of the three different circuits on a daily frequency interval from three shifts. The samples were labelled and were colour coded using sampling bags of different colours per coal seam. The sampling bags were labelled both inside and outside the bag and tightened with a cable tie. Double bags were used to avoid tearing of the bags and losing of the sample. This would then be dispatched to the laboratory for floats and sinks analyses. Sampling of the spiral was done on the discard screen.

5.3 Wemco feed bin flopper control philosophy

The wemco section has two wemco drums that are fed by two surge bins and feed to the surge bins is controlled by a flopper that was controlling the two bins at a 50% feed split.

6 Results

6.1 A Wemco size split

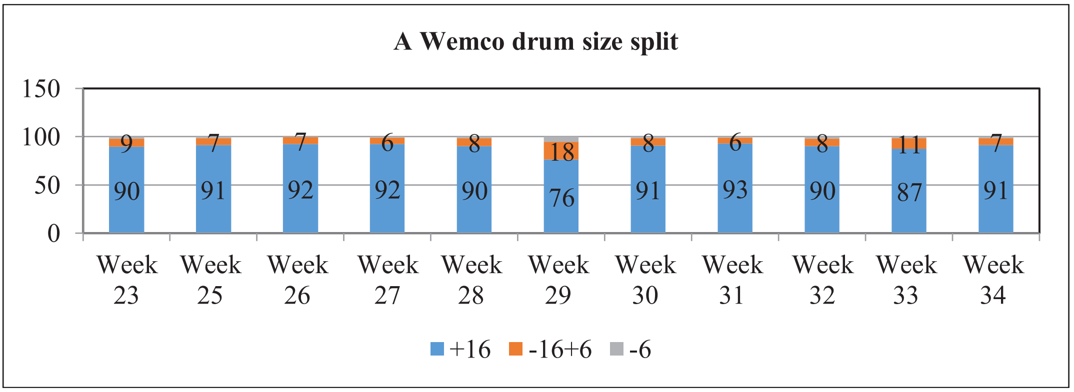

Fig. 7. A wemco size split results

The size split results on general showed that A wemco is averaging 90% on the +16mm material and 10% on the -16+6mm. This aligned to the required minimum particle size of 6mm as according to the literature.

6.2 B Wemco size split

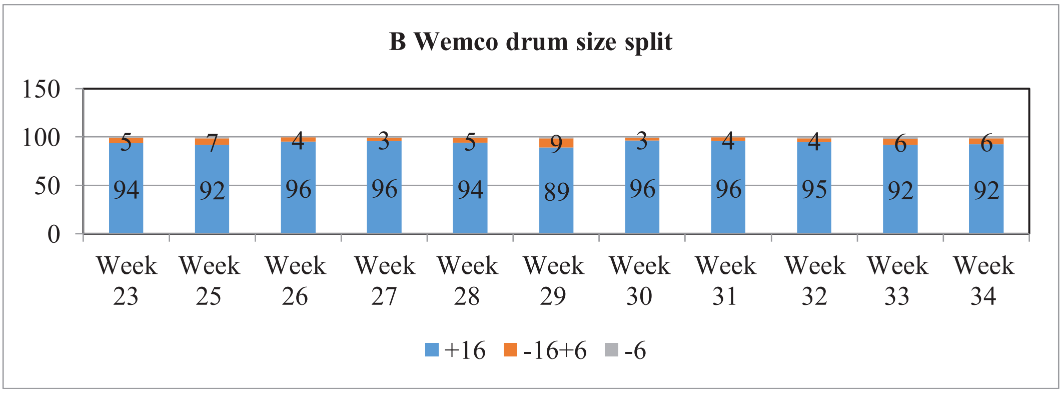

Fig. 8. B Wemco size split results

The size split results on general showed that B wemco is averaged 94% on the +16mm material. The -16+6mm is on 6% which is within specification.

There was a slight difference in terms of the size split on A and B wemco looking at the +16mm material. This was expected and can be explained in terms of the transfer of material from C9 conveyor to A2 conveyor via the transfer chute which allowed segregation to occur leaving fines to land on the first section of the conveyor and coarse material landing a bit further. This segregation remained on the conveyor up to the discharge of A2 conveyor where the fines already on the side of A wemco bin are discharged into A wemco leaving most of the coarse material to land into the B wemco bin. This was also evident on the discard washability results in that B wemco was expected to beneficiate coal efficiently more than A wemco because of the difference in the +16mm material.

6.3 DMS cyclones size split

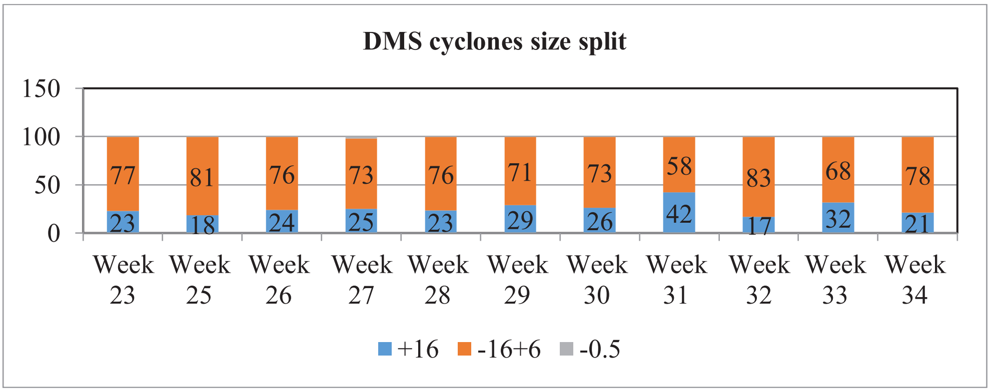

Fig. 9. DMS cyclones size split results

The DMS cyclones showed +16mm material of 26%. On the -16+0.5mm showed 74% and the -0.5mm fraction had generally none. This showed efficient classification and that the DMS cyclones were receiving the correct particle size distribution.

6.4 Observations and findings from results

The wemco drums showed an imbalance in the feed distribution and further showed a bit of fines were entering the circuit in the form of -6mm material fraction. This on the A wemco was 2% and 1% on B wemco. The classification of the wemco drums therefore showed some optimisation work was needed for feed particle size distribution to both wemco drums. No work was required on the DMS cyclones as the feed particle size distribution was correct. This sampling campaign on the modular misplacement samples was done from August 2016 to August 2024.

To revisit the graph presented earlier now in figure 10, option 1 considered was to try and install deflecting plates on the wemco feed conveyor to eliminate segregation in September 2020 to October 2021. The challenge with the deflecting plates was that they were getting worn out and the segregation challenge would then take effect again. It was also not easy to inspect the deflecting plates while conveyor was on coal during normal production time.

The second resolution trialled was to install a scrapper on the head chute of the feed conveyor in the same period to eliminate fine coal build up in the dribble chute at the time which would end up in A Wemco. Although this proved to be successful, it was no longer required as optimisation work that would later be done on the banana screens eliminated the challenge of fine coal material fed to the wemco drum section.

Lastly the implementation of APC (automatic process control) in the period 2020 to 2022 was also effective in implementing a philosophy that would allow controlling of the trolley feeding the A and B banana screens.

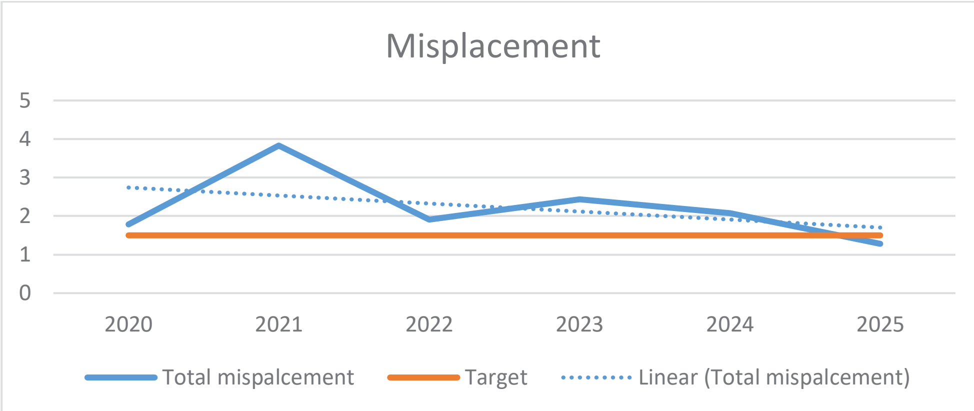

Fig. 10. 2020 to 2025 misplacement results

After the above resolutions were not sustainable, it was then time to optimise on screening efficiency and classification. This was to be tackled in 2 ways, by looking at the classification on the banana screens and the feed distribution on the wemco feed bin flopper. Figure 11 shows the banana screen panel configuration for A (16mm,20mm panels) and B (12mm panels) banana screens. The two screens are fed with a trolley controlled by APC looking at the bin level ahead of the screens for level control. A PSA (particle size analyser) is also used to direct the trolley to the correct banana screen based on the particle size distribution. If the duff bin level gets to a higher level the trolley will feed material to the small aperture B banana screen therefore reducing screening efficiency and sending -6mm material to the wemco drums. To resolve this the panel configuration needed to be changed to 20mm on both screens to prevent finer material in the wemco drum which was implemented.

Further to that the philosophy on the wemco feed bin flopper was reviewed to avoid starvation on any of the wemco drums. The philosophy implemented was that the flopper will only move to the other bin once the wemco feed bin level is at 85% and the second bin is on 75%. In this way no wemco drum will be starved and by movement of the flopper the wemco feed bins get equal feed distribution.

Fig. 11. A and B banana screen panel configuration (August 2020 to February 2024)

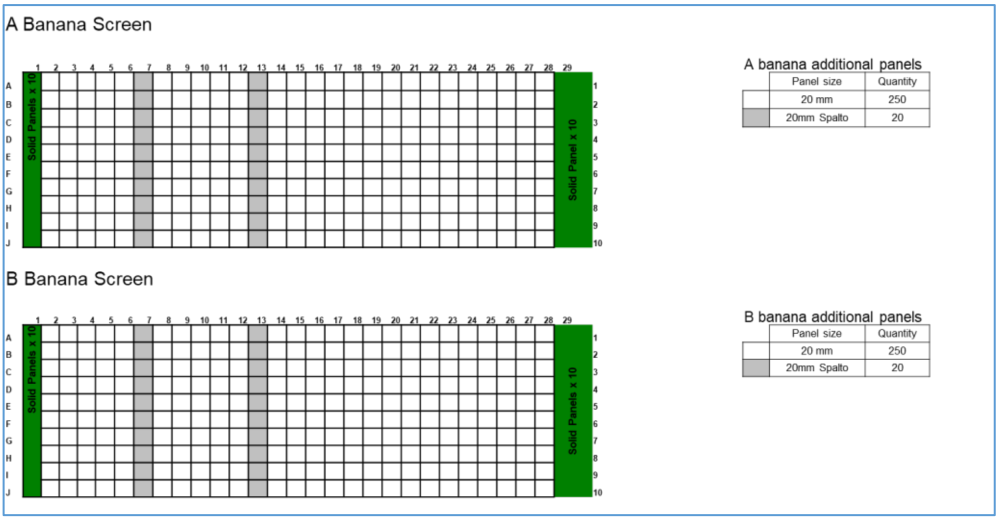

Fig. 12. A and B banana screen panel configuration February 2024 to date

A key additional change was to understand why the duff bin (feed to cyclones) was constraining the circuit where either feed was cut back, or adjustment to feed less fines (feeding the 12mm deck) and thus misplacing the fines into the Drums. It was identified that the Duff bin discharge conveyor rate was a constraint. A change of the gearbox was done on the 15 January 2024 date, which allowed more feed to the duff bin as the discharge rate was higher.

This enabled the change of the panels on the banana screens to 20mm on both screens from the 12mm panels and stopped the practice of using the screen misplacement as a lever to control the duff bin level. This has a significant improvement in misplaced fines to the WEMCO circuit and significantly reduced misplacement.

6.5 Results after changes made on screens and flopper

With the implementation of the changes done and changes done on A2 flopper end of 2024 showed the misplacement results to be dropping. This showed the segregation issue was resolved, and the issue of fines carry over was also resolved.

Month	WEEK	Weekly Misplacement	Monthly Average
Jan	W1		0.80
	W2	0.68	
	W3	0.38	
	W4	1.33	
Feb	W5	1.03	1.03
	W6		
	W7		
	W8		

Fig. 13. Composite misplacement results for 2025

7 Conclusions and recommendations

- Composite misplacement samples were sampled on a hammer sampler and analyses made from the composite sample showed higher misplacement values through the DMS cyclones and low misplacement values on the wemco drum. After changing the sampling methodology to a modular misplacement method showed the root cause of misplacement as the wemco drums, demonstrating the importance of correct interpretation of composite samples and the need for required detailed investigations.
- Classification in the DMS cyclones has not been a challenge throughout which showed that no further investigations were required.
- The feed split and imbalance between the two wemco drums initially showed some optimisation work was required through the wemco feed bin flopper. This was done through the implementation of the new philosophy using the feed flopper by keeping both bins at maximum 85% and low 75% feed bin level. This philosophy ensured that no wemco drum has been starved of feed and that the feed distribution is done evenly for the two wemco drums.
- The biggest impact on improving the WEMCO drum misplacement, was ensuring the correct control of the feed rate/PSD into the WEMCO/Cyclone circuit, by deconstraining the duff bin discharge conveyor and stopping the use of PSD as a lever but rather ensuring the screens are set with the right panel size to minimize misplaced fines into the WEMCOs. This has significantly improved the misplacement in the WEMCO circuit and overall at Goedehoop.

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