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An evaluation of the classification process within grassalco's gravity concentrating plant at maripaston, district para-suriname

Uma avaliação do processo de classificação dentro da planta de concentração gravitacional em maripaston, distrito para-suriname

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ABSTRACT

In 2014 started the states mining company of the government, N.V. Grassalco a pilot mining operation at Maripaston using a gravity concentration plant to process the tailing of the small scale gold miners that consist of free and associated recoverable gold. This plant consists of a Hammer mill, four Centrifugal concentrators, a Hydro cyclone, a Ball mill, and a Shaking table in the gold room. This project was carried out to evaluate the classification process of the hydro cyclone in this gravity concentrating plant and for this evaluation the apex diameter and discharge type, percentage solid, and particle size distribution were taken into account. To study the performance of the Hydro cyclone, the feed, underflow, and overflow were sampled and analyzed. The results obtained showed that the d_{80} determined during this project was between 500 µm and 700 µm, while N.V. Grassalco applies a d_{80} size of 63 µm, and the sharpness of separation was between 0.5 and 1.1, while according to some researchers the sharpness of

separation of a good classification process lies between 0.2 and 0.4. It was also observed that the discharge type of the underflow was roping. Based on these findings can be concluded that the Hydro cyclone did not perform well.

Keywords: classification; hydro cyclone; performance; small scale gold miners tailing.

RESUMO

Em 2014, a empresa estatal de mineração do governo, N.V. Grassalco, iniciou uma operação piloto de mineração em Maripaston, utilizando uma usina de concentração por gravidade para processar o rejeito de mineradores de ouro de pequena escala, que consistem em ouro recuperável livre e associado. Esta planta consiste de um moinho de martelo, quatro concentradores centrífugos, um ciclone hidráulico, um moinho de bolas e uma mesa de agitação na sala dourada. Este projeto foi conduzido com o objetivo de avaliar o processo de classificação do hidrociclone nesta planta concentradora e, para esta avaliação, foram considerados o diâmetro do vértice e tipo de descarga, porcentagem de sólidos e distribuição de tamanho de partícula. Para estudar o desempenho do ciclone Hydro, a alimentação, underflow e overflow foram amostrados e analisados. Os resultados obtidos mostraram que o d80 determinado durante este projeto foi entre 500 µm e 700 µm, enquanto NV Grassalco aplica um tamanho d80 de 63 µm, e a nitidez de separação foi entre 0,5 e 1,1, enquanto de acordo com alguns pesquisadores a nitidez da separação de um bom processo de classificação situa-se entre 0,2 e 0,4. Observou-se também que o tipo de descarga do underflow foi roping. Com base nesses achados, pode-se concluir que o ciclone Hydro não teve bom desempenho.

Palavras-chave: classificação; ciclone hidratado; desempenho; mineiros de ouro em pequena escala.

1. INTRODUCTION

Classification within mineral processing is defined as a method of separating mixtures of particles by size into two are more products according to their settling velocities in water, air or other fluids. Useless material is removed from an operation circuit, or material is prepared for another unit operation. Classification processes are affected by geometrical factors, operational factors, and physical properties of the material to be classify. N.V. Grassalco; a mining company of the Surinamese government, uses a hydro cyclone with an inner diameter of 15”, inlet pipe of 4”, and vortex finder size of 6” in its gravity concentration plant to classify the output of four centrifugal concentrators removing fine unwanted particles from its circuit, while the coarse particles are send to a ball mill for further grinding. The plant (where the tailing of the small scale gold miners that consist of free and associated recoverable gold is processed) also consists of a Hammer mill, a Ball mill, and a Shaking table in the gold room. As part of a screening project of this company the classification process of the hydro cyclone was studied and evaluated if it met the requirements and expectations of the company. The objectives of this study are to: determine the physical properties of the hydro cyclone flows, determine the

particle size distribution (PSD) of the hydro cyclone samples, and to study the effect of the solid percentage, PSD, and apex diameter on the classification process of the hydro cyclone.

2. METHODS AND TECHNIQUES

The methods and techniques applied during this project are divided into fieldwork, and laboratory work. The fieldwork was carried out at Maripaston district Para Suriname, where the gravity concentration plant of N.V. Grassalco lies, and consisted mainly of sampling and sample preparation for transport to the Anton de Kom University of Suriname where the laboratory work was carried out. The laboratory work consisted of sample preparations, PSD determination, and particle size analyses. The circuit of N.V. Grassalco and the sample points are shown in figure 2.1. The hydro cyclone's feed (PC and SC), underflow (HUF) as well as its overflow (HOF) was sampled measuring the time, mass and volume of each sample for the calculation of the mass flow, volume flow, %solid and density. Slurry was collected for 3 days spreading over 4 weeks with an apex size of approximately 1.7'' and 1.9". Each sampling day consists of 3 or 4 sampling moments. The daily samples were air-dried and homogenized using the elongated long pile method to reach a sample weight of 5 kg. A micro sample splitter was used to split the samples until the 5 Kg sample was reduced to approximately 1 Kg, needed for the PSD tests.

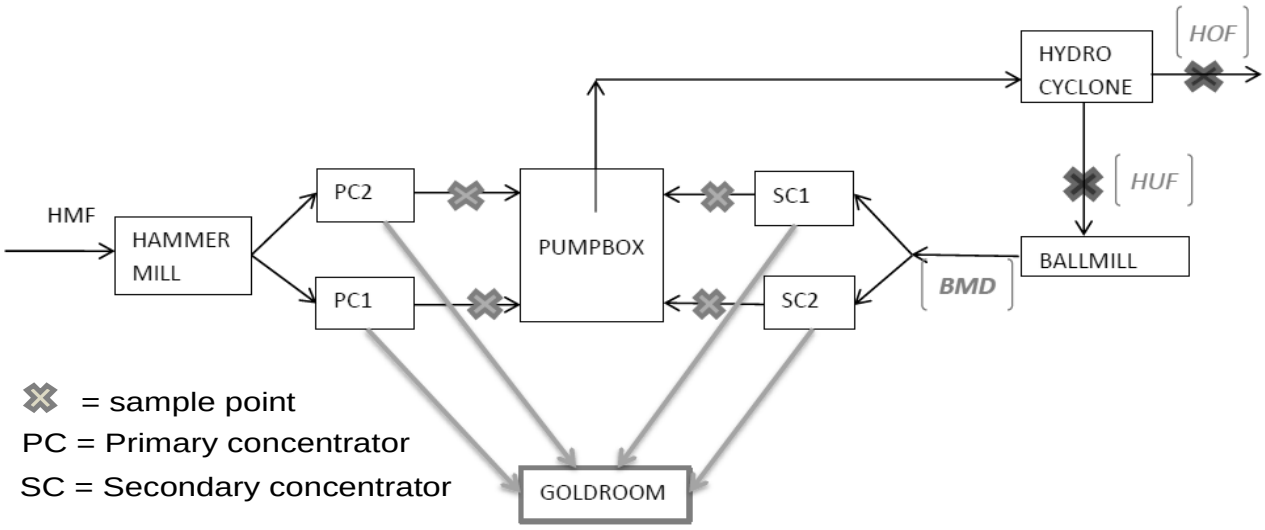

Figure 2.1. The circuit of N.V. Grassalco

To determine the particle size of the samples wet-sieve was applied using the sieve openings of 125 µm, and 63 µm, and a stack of sieve (2000 µm, 1000 µm, 500 µm, 250 µm, 125 µm, and 63 µm) to dry-sieve the retained material of the wet- sieve. The feed of the hydro cyclone was defined as $F_{calculated}$ and $F_{pumpbox}$, with $F_{calculated}$ being the results of the underflow

(C) plus the results of the results of the overflow (T), and $F_{pumpbox}$ being the results of the discharge of the 4 centrifugal concentrators of N.V. Grasssalco (PC1, PC2, SC1, and SC2). Equation 2.1 A was used to calculate the imperfection or sharpness of separation, while equation 2.1 B was used to calculate the corrected sharpness of separation.

$$I = \frac{d_{75} - d_{25}}{2d_{50}} \quad (\text{Wills \& Napier} - \text{Munn}, 2006) \qquad (2.1\ A)$$

$$I = \frac{d_{75c} - d_{25c}}{2d_{50c}} \quad (Heiskanen, 1993) \qquad (2.1\ B)$$

For this correction it was necessary to also calculate the water recovery Rf, the real partition P_{real}, and the corrected partition $P_{corrected}$ (equations 2.2, 2.3, and 2.4).

$$Rf = P_{real\ H2O} = \frac{C_{H2O}}{F_{H2O}} \times 100\% \quad (Heiskanen, 1993) \qquad (2.2)$$

$$P_{real}(\%) = \frac{C\ (ton/h)}{F\ (ton/h)} \times 100\%\ , \text{where } C = \text{concentrate}\ \ (Heiskanen, 1993) \qquad (2.3)$$

$$P_{corrected}(\%) = \frac{P_{real}(\%) - Rf}{100 - Rf} \quad (Heiskanen, 1993) \qquad (2.4)$$

3. RESULTS AND DISCUSSIONS

3.1 SAMPLING RESULTS

In table 3.1 can be seen that the discharge type of the hydro cyclone was mainly roping on the sampling days.

Table 3.1. Results of the hydro cyclone underflow discharge type

Hydro cyclone underflow Discharge type		
Apex size is 1.5"	Apex size is 1.7"	
Day 1	Day 2	Day 3
Roping	Semi spray	Roping

3.2 SOLID PERCENTAGE

Table 3.2 shows the calculated mass flow, mass percentage, volume flow, and the density of the dried solid of the hydro cyclone underflow (HUF) and overflow (HOF). The table also shows the solid feed flow of the cyclone. The solid mass flow of HUF was the lowest on day 3 valued 7.40 t/h, and the highest on day 2 with a flow of 10.13t/h. This means that there was less solid flowing to the underflow on day 3 compared with the other sampling days, and more solid flowing to the underflow on day 2 compared with the other sampling days. The HOF solid mass flow on day 2 and 3 show little difference. On day 1 the HOF solid mass flow was the highest valued 12.45t/h. The solid mass flow of F_{box} and $F_{calculated}$ differ 1.04 - 2.31 t/h from each other. It can also be seen from the table that on day 2 the %solid of HUF was 51.85 %, lying in the solid percentage range of 55-60% that N.V. Grassalco applies for the HUF. The solid density of the HUF as well as the HOF laid around1.7 t/m^3.

Table 3.2. Results of the solid mass flow, mass percent, volume flow, and the density of HUF and HOF

Sampling day	Solid											
	Mass flow (t/h)				% mas				Volume flow (m3/h)		Density (t/m3)	
	HUF	HOF	Fcal.	Fbox	HUF	HOF	Fcal.	Fbox	HUF	HOF	HUF	HOF
Day 1	8.59	12.45	21.04	18.73	71.32	26.82	36.00	33.14	5.16	7.24	1.67	1.72
Day 2	10.13	5.37	15.50	16.54	51.85	12.93	25.38	32.49	5.83	2.86	1.74	1.88
Day 3	7.40	5.90	13.30	15.88	71.79	15.58	27.60	25.66	4.36	3.85	1.70	1.53
Average	8.71	7.91	16.61	17.05	64.99	18.45	29.66	30.43	5.12	4.65	1.70	1.71

Table 3.3 shows the results of the water recovery on the sampling days, the overall mass recovery (P_{real}), and the corrected mass recovery ($P_{corrected}$). For the determination of the results of table 3.3 equation 2.2, 2.3, and 2.4 was used. Rf1 is calculated using $F_{calculated}$, while Rf2 is calculated using F_{box}. The water recovery (bypass) calculated with $F_{calculated}$ gives a higher water recovery than Rf 2 except on day 2 shown in table 3.3. On day 2 the water recovery of the feed in the underflow was above 20%. According to Napier-Munn, et al. (1996) water recoveries between 20 and 30% can result in good solid classification efficiency.

Table 3.3. Results of the water recovery and mass recovery

Sampling day	Rf 1 (%)	Rf 2 (%)	Preal1	Preal2	Pcor. 1	Pcor. 2
Day 1	9	8	41	46	35	41
Day 2	21	25	65	61	56	48
Day 3	8	6	56	47	52	43
Average	13	13	54	51	48	44

Preal1 is determined using $F_{calulated}$, while Preal2 is determined using F_{box}. It can be seen that an average of 54% and 51% of the solid in the pump box recovers into the underflow of the cyclone. After correcting the mass recovery with the bypass data Pcor.1 and Pcor.2 showed a mass recovery average of 48% and 44%. The mass recovery determined with $F_{calculated}$ shows a higher recovery, except on day 1. The results of table 3.3 showed that the mass recovery to the underflow on the sampling days increased, when the apex size increased.

3.3 PSD ANALYSIS

Figure 3.1 show the results of the particle size distribution (PSD). It is noticeable that the overall particle size concentration (PSC) of the cyclone lies between 1000 µm and 250 µm. It is also noticeable that the HUF had the same PSC as $F_{cal.}$ on the sampling days. The particle size concentration of HOF lying between 1000 µm and 250 µm shows a displacement to the range lying between 500 µm and 125 µm when day 1, 2, and 3 are compared with each other.

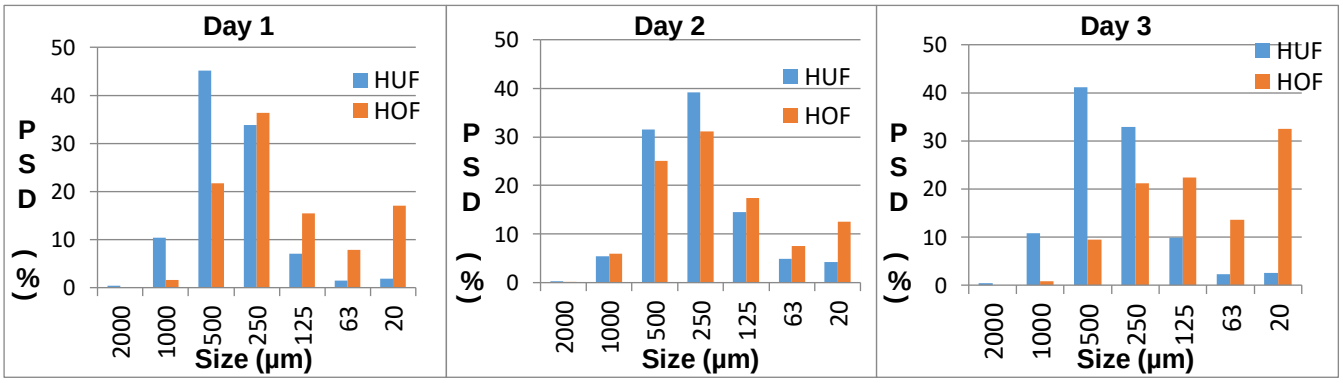

Figure 3.1. Results of the PSD

Table 3.4 shows the results of the d_{80} cut size of the overflow, and the percentage particles smaller than 63 µm in the overflow. It can be seen from the table that the d_{80} size laid between 385 µm and 724 µm. The d_{80} size that N.V. Grassalco applies is 63µm. Table 3.4 shows that none of the sampling days measure up to that requirement. The table also shows that the highest percentage particles smaller than 63 µm in the overflow was on the 3th sample day, valued 32.5 %.

Table 3.4. Results of the d_{80} size and HOF percentage particles < 63 µm

HOF	Day 1	Day 2	Day 3
d80(µm)	575	724	385
< 63 µm (%)	17.1	12.6	32.5

Table 3.5 displays the results of the d_{50} cut size and the separation efficiency. The cut size and imperfection on day 2 could not be determined, because of the P_{real} and $P_{corrected}$ mass recovery being smaller than 75%, and containing multiple particles sizes with 50% mass recovery. Table 3.5 shows the d_{50} and d_{50c} cut size lying between 199 µm and 350 µm. Table 3.5 also shows that the sharpness of classification (I) lied between 0.7 and 1.1 on the sampling days. According to Wang et al. (2000) a sharpness of classification between 0.2 and 0.4 may be interpreted as a good classification process.

Table 3.5. Results of the cut size and imperfection

	Day 1			Day 3		
	Preal	Pcor.1	Pcor.2	Preal	Pcor.1	Pcor 2
d75	722	779	773	408	434	426
d50	294	353	348	199	216	211
d25	105	141	136	99	105	115
I	1.05	0.90	0.92	0.78	0.76	0.74

3.4 GOLD CONTENT

Figure 3.2 shows the results of the gold content. It can be notice that on day 1 and 3 the gold particle size concentration of the HOF and HUF laid between 1000 µm and 250 µm. This size range was also seen for the on sieve results of figure 3.1. On day 3 the particle size concentration of the HOF material displaced from the range between 1000 µm and 250 µm to the range between 500 µm and 125 µm. The gold particle size concentration was smaller than 63µm on that day.

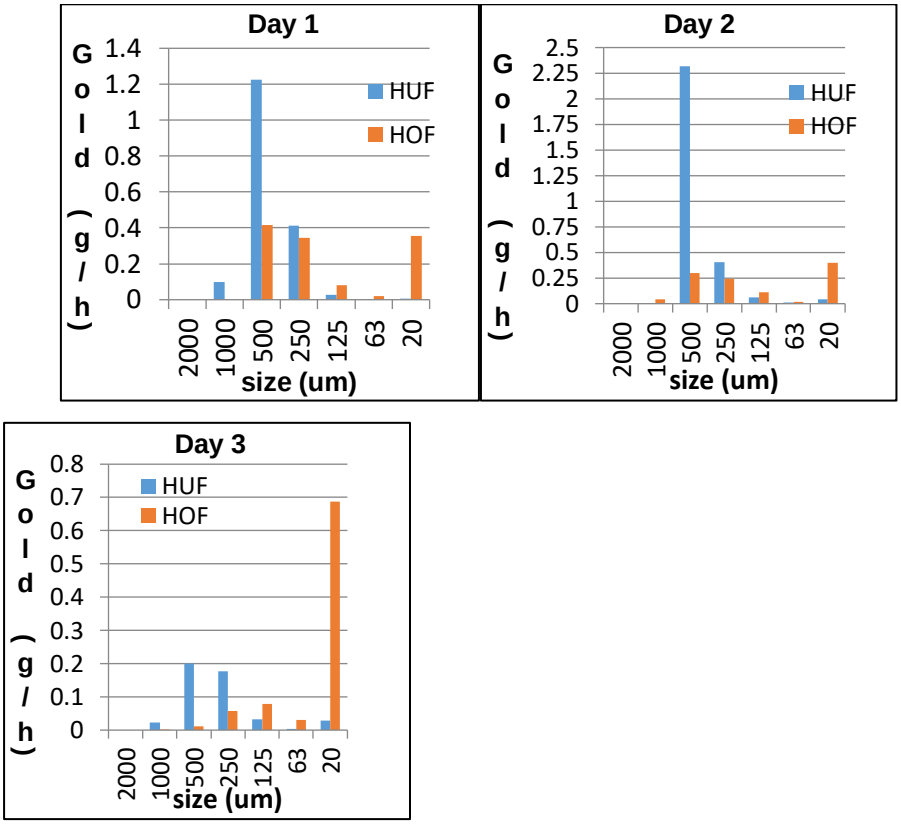

Figure 3.2. Results of the gold flow

Table 3.6 shows the results of the HOF gold flow and particle size on the sampling days. It can be seen that on day 1 and 3 the HOF consisted of a percentage gold flow between 48% and 62% for the particle size between 1000 µm and 250 µm. The expectancy of N.V. Grassalco for the cyclone is that particles coarser than 125 µm will report to ball mill, so that gold particles trapped in the gangue material will be grind and liberated, and concentrated afterwards by the centrifuges. Particles smaller than 63µm should report to the overflow and into the tailings pound, because the centrifuges of the company works the best between 125 µm and 40 µm, and it is expected that the Ball mill discharge will be between 125 µm and 40 µm.

Table 3.6. HOF gold results on the sampling days

Sampling day	Total gold-flow (g/h)	Gold concentration	
		(µm)	(%)
Day 1	1.221	,-1000 +250	62.4
Day 2	1.111	,-1000 +250	48.2
Day 3	0.867	< 63	79.2

4. CONCLUSIONS

From the results of this project may be concluded that: The operating conditions of the hydro cyclone are: An average solid percentage of 67.4 % for the HUF, 19.3% for the HOF, and 31% for the feed. An average solid flow of 8.88 t/h for the HUF, 8.27 t/h for the HOF, and approximately 17 t/h for the feed.

The cyclone of N.V. Grassalco does not perform well as a classification device. This was concluded because of the "roping" discharge type of the underflow during sampling. The roping discharge caused coarse particles to report to the tailing (overflow) instead of the underflow. This was shown by the particle size concentration in the overflow with more than 50% of particles between 1000 µm and 125µm. The sharpness of classification results also showed that the cyclone does not perform well as a classification device. The sharpness of classification on the sampling days was between 0.5 and 1, and according to Wang et al. (2000) that is not a good classification process. The fact also that on the sampling days a percentages of more the 58% of the total gold flow lying between 1000 µm and 125 µm reported to the overflow, shows that the hydro cyclone does not perform well.

Although the apex diameter is a parameter that affects the classification process of the hydro cyclone, its effect on the results during this project could not be obtained. And although the hydro cyclone does not classify well the decrease in feed %solid during this project may have caused a better classification process comparing the sampling days with each other.

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