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Design and Experimentation Shaking Table Tool for Gravity Concentration Metal Mineral Separation

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Abstract: Mineral dressing, especially metal minerals in Indonesia, is carried out using appropriate methods based on their properties and characteristics. The method often used is gravity concentration. The technology that makes use of it is a shaking table. This tool works based on the difference in specific gravity and particle size in the flowing film concentration which exerts a thrust against the particles on the deck. In an effort to meet the needs of practicum and research in the mining engineering department, especially the Sriwijaya University Mineral Processing Laboratory. For this reason, the existing equipment in the laboratory is modified by changing the design and size of its main components. The deck is designed with a length of 170 cm and a width of 102 cm. The riffles are installed parallel to a height of 3 mm, a width of 1 cm and a spacing of 3 cm. Experimentation is carried out by adjusting the variation of the variables. The variables used as parameters are deck slope (4°, 6° and 8°), water flow rate (10, 12 and 15 L / min) and feedingspeed (5, 10 and 15 minutes). The sample used was refined tin ore. Sampling at two locations, namely sample A at the Bantam B122 Collection Station, Belinyu and sample B at the TKT DU1521 Jangkang Washing Plant Station.

Keywords: Shaking Table, Deck, Riffle, Recovery

1. Introduction

Gravity concentration is a concentration process to separate precious mineral grains from mineral impurities based on differences in specific gravity in a medium in the form of water or heavy liquid or suspension of solids in water. Separation occurs based on differences in the motion of mineral grains in the liquid caused by gravity and one or more other forces acting together on the grains.

In gravity concentration, the number of grain masses and the shape of the mineral grains have an influence on the relative movement of grains in flowing water, namely the movement of grains in the vertical plane or stratification, and movement in an inclined plane in the flowing film concentration [6]. Apart from the specific gravity of the grain size of the mineral also affects the speed of movement of minerals in the separating medium. This relates to the value of the terminal velocity of the mineral in the separating medium [6].

The concentration criterion (KK) is an estimate of whether the gravity concentration process can be applied to separate minerals that have different specific gravity and size intervals that can be used and specifically to assess the level of difficulty of separation. KK is the relationship between the specific gravity of heavy minerals, impurities, and the fluid used for separation [6].

The working mechanism of the head motion tool begins with the process when the rocking table is not being operated, the spiral spring is in an elongated or stretched condition and the toggle is horizontal. When the rocking table is started, the 2 pitmans move eccentrically so that the toggle is tilted. As a result, the table deck moves back or forth until the pitman tilts to the topmost point and the spiral springs close. Then the pitman moves down again so that the toggle is level again and the spiral spring is stretched again. As a result, the table deck moves forward again. The back and forth motion keeps repeating when the rocking table is operated. The movement is asymmetrical because the backward movement (pull) is stronger than the forward movement (push) [3].

The slope of the deck plays an important role in rocking table operations which ranges from 6°-10°. The slope of the deck can be adjusted by turning the screw valve at the bottom of the deck. The inclined connector is the connection

between the deck and screw faucet. The slope of the table and the flow greatly affect the grade of tin ore and the weight of the grade produced. [3]

If the riffle height is very high then the eddy currents are not able to stir and lift the particles that are in the lowest layer in the inter-riffle area. Therefore, coarse particles that have large diameters require high riffles while fine particles require low riffles [6].

Riffle on the table serves to cause rotating currents (eddy currents) around it. The current stirs and lifts the particles caught between the riffles [3].

The influence of grain size on recovery in the tabling/shaking table method of various minerals such as cassiterite, wolframite, and iron ore also explains that particles measuring (5 m) can be separated using the tabling method so that with increasing particle size, concentrate gain will increase. [3]

In this study, there are 3 important stages in the design, namely the design and design of the shaking table that will be made, calculations and the head motion system that will be used and conducting experiments to test the functions of the designed shaking table.

The metallic mineral that will be sampled is tin ore from PT TimahTbk. The main mineral tin ore (cassiterite) is the main product of the washing process, where the shaking table is still the mainstay for separating the main mineral cassiterite tin ore from the impurity mineral quartz. In testing the tin ore samples came from 2 different locations. the recovery of valuable minerals with the percentage of impurity minerals will be calculated.

The results of this experiment can be seen whether the trend line of the mineral separation scheme has been running optimally. The test results will be evaluated so that the important parameters that affect the mineral separation of the shaking table device can function properly as a tool used to separate metal minerals by gravity concentration. The expected final result with this shaking table is that in addition to enriching the lecture material, it can also be used for practicum for Mining Engineering students. Besides, it is hoped that it can be used for lecturer research and student final assignments with different variables.

2. Research Methods

In this research, there are 2 important stages: the first: the design and assembly of the shaking table and the second is the experimentation with tin ore samples from PT. Timah, Tbk Bangka.

Design and modification activities as well as sample testing experimentation were carried out at the Mineral processing Laboratory, Department of Mining Engineering, Faculty of Engineering, Sriwijaya University.

The design by modifying the design of the shaking table was preceded by conducting an initial study of literature and comparative studies at the Tin Ore Washing Center at PT TimahTbk, Bang Kabelitung Province. A study to obtain a real picture of the conditions and identify problems with the shaking table under study. And to simplify the research

process, currently the shaking table is still being used to separate tin ore (cassiterite) from impurities based on differences in BJ.
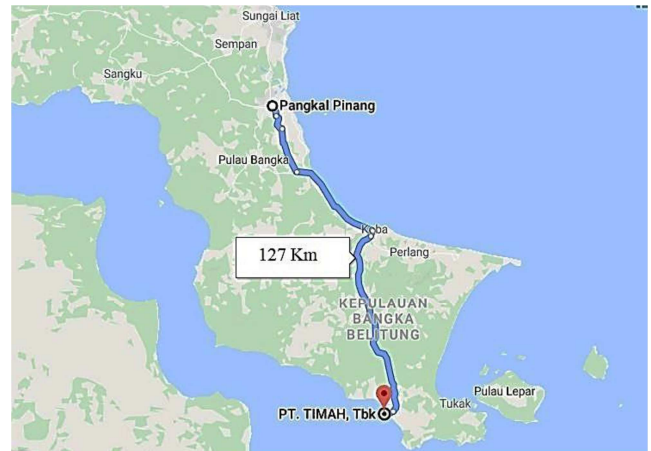

Figure 1. *Research locations and activities for tin ore sampling.*
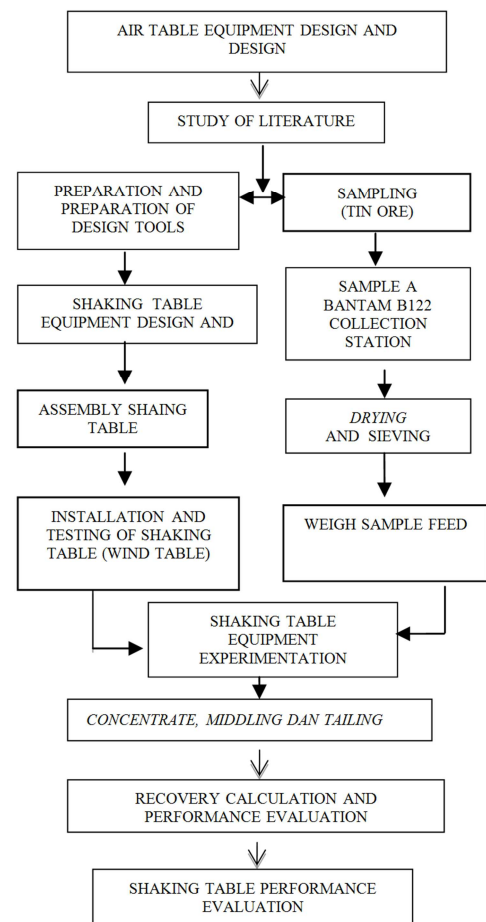

Figure 2. *Research Flowchart of Shaking Table Tool Design.*

The next activity is to observe and measure the capacity and power of the shaking table for a laboratory scale. This activity aims to see the results of observations used as the main parameter in making the design of the modification of the tool. In addition, in this activity measurements were made of the components of the modified tool. The size of each component is used for making the draft design.

The sample used in the experimental design of this shaking table is tin ore. The sample used as research material consisted of two types of samples taken from different locations. Sampling was carried out at two locations, namely sample A at the Collecting Station B122 Bantam, Belinyu as much as 43 Kg and sample B as much as 27 Kg at the Washing Plant TKT DU1521 Jangkang Station belonging to PT. Timah, Tbk. Sampling is done by taking some of the tin which is used as a representative of the tin pool to be tested.

3. Discussion

The design was completely carried out at the Mineral Processing Laboratory, Faculty of Engineering, Sriwijaya University. The modified design was made based on the evaluation of the information from the observations and the literature that had been collected. From this evaluation, it is known that not all components need to be modified. The modifications made were to change the material and add the necessary components. In accordance with its function, the shaking table is a tool to separate precious metal minerals (concentrate) and impurity minerals (tailings) based on the nature of differences in specific gravity. / research lecturers and students for the final project.

Figure 3. Results of Deck Shaking Table Design.

Modification of the design is done by changing the design and size of the components that make up the tool. Design and Modification of the shaking table which was designed to produce a Wiffley Table type device (Figure 1). And the table drive system (head motion) uses a pulley system. The table will be driven by an electric motor with a stroke length and number of strokes per minute.

a. Table / Deck Design Results

The first stage of design is by designing a deck table or table mat designed using rubber as a base material. The type of rubber used is EPDM Rubber Sheeting with a thickness of 5 mm. The selection of this type of rubber is seen from its superiority with its high resistance to water abrasion. The deck is designed with a size of 170 cm x 102 cm (Figure 4).

The second stage is the entire surface of the table/deck after rubber has been installed as a base, then a riffle will be designed and installed parallel to a certain distance. The number of riffles that this tool has is 21 pieces with a height of 3 mm, a width of 1 cm. The installation of the riffle on the deck is set at a distance of 3 cm.

b. The results of the design of the table/deck

Figure 4. Results of Table/Deck Design and Installation of Rubber and Riffle Mats.

c. The result of the design of the propulsion machine

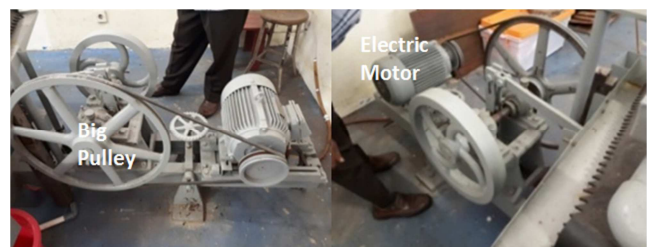Figure 5. Shaking Table Drive System Electric Motor Pulley System.

The driving machine serves to move the table that has been designed with the measured power. The electric motor that is installed to run the shaking table is a machine with a three-phase induction motortype C122M-4.

The resulting speed of this type of motor is 1440 rpm. This motorized machine has the power to move the table with a

power system through a pulley system so that it will move with a stroke length of less than 5 cm and a number of strokes of 140 strokes per minute with a motor power of 5 HP and a voltage of 220/380 V, 3 phases (Figure 5).

d. The results of the shaking table system design

Results The design and assembly of the shaking table as shown in Figure 6 has been systemized and ready to be used.
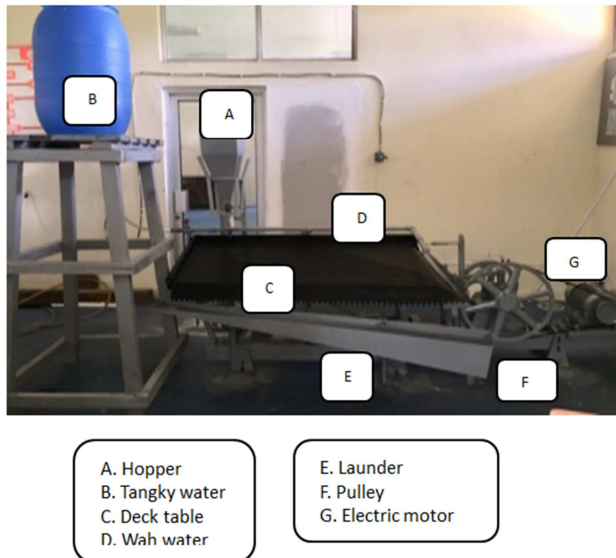

A. Hopper
B. Tangky water
C. Deck table
D. Wah water
E. Launder
F. Pulley
G. Electric motor

Figure 6. *Results of the Shaking Table Tool Design that has been installed in the Mineral Processing Laboratory.*

In addition to the deck and propulsion engine, this tool is equipped with 4 main components: (1) a table (deck), (2) a driving engine, (3) a wash water system where water from tedmon (150 liters) is flowed through a pipe made of stainless material steel. The size of the pipe used is a pipe with a diameter of inch or 1.905 cm. The surface of the pipe is perforated as many as 16 holes with a distance of 7 cm.

The function of the tool is to wet the table (deck) as a water medium to separate minerals on the surface of the deck by retaining the riffle, (4). Hopper feed, serves to regulate the rate of feed sample feed as a feed regulator and adjusted to

capacity. Another tool that is no less important is a launder to accommodate the results of the mineral separation process according to the separation zone to accommodate the results of 3 products, namely concentrate, middling and tailings. Handling of the remaining water as a separating medium will be accommodated with a bucket, which is at the bottom of the shaking table.

b. Shaking Table Tool Experiment Results

The aim of the experiment is to determine whether the device is working properly or not, so that it will be used as an evaluation so that the shaking table can work optimally in the future. In the experiment the sample used was tin ore from PT TimahTbk. Sampling was carried out at 2 locations; Location A Collection Station B122 Bantam, Belinyu is declared as Sample A (weighing 43 Kg). Size distribution analysis results Sample A average size 20 # - 30 #

Meanwhile, Location B of Washing Plant Station TKT DU1521 Anchors (weighing 27 Kg) was assigned as Sample B. The results of the size distribution analysis Sample B average size 20 # - 30 #

In the experimental test of tin ore, the main variable used is the slope of the deck. The slope deck is the main variable for separating valuable minerals and impurity minerals based on specific gravity.

$$F = m.\ g.\ Sin$$

Where:
F=thrust
m=mass of feed / weight of feed (kg)
g=gravitational force (9.8 kg m per second²)
=slope of the table (slope of deck)
Standard deck slope=3° – 10° [3]

In the experiment the research variables used were slope of deck, (°), debit (liters/minute) and sample feed speed (minutes). Each variable was tested with three variations (combination of variations: S, Q, and F), so that each combination resulted in 9 variations of the combination, (27 trials). The success of the separation can be seen from the value of the concentrate obtained.

Table 1. *Experimental results of shaking table.*

No	Combination of Variable	Sample A			Sample B		
		K	M	T	K	M	T
1	S1Q1F1	100.40	38.50	61.10	99.9	38.5	61.5
2	S1Q1F2	110.50	33.90	55.60	105.2	31.9	62.9
3	S1Q1F3	118.90	25.80	55.30	111.9	25.9	62.2
4	S1Q2F1	108.50	35.30	56.20	107.3	35.2	57.5
5	S1Q2F2	122.10	28.80	49.10	114.1	29.0	56.9
6	S1Q2F3	132.10	20.20	47.70	120.9	24.6	54.5
7	S1Q3F1	118.10	32.00	49.90	115.0	32.0	53.0
8	S1Q3F2	127.40	26.00	46.70	120.3	26.6	53.1
9	S1Q3F3	138.20	18.00	43.80	126.5	22.4	51.1
10	S2Q1F1	106.50	36.40	57.10	104.3	36.9	58.8
11	S2Q1F2	114.20	32.90	52.90	109.3	29.6	61.0
12	S2Q1F3	122.90	20.00	57.10	116.9	24.9	58.2
13	S2Q2F1	116.10	33.00	50.90	112.2	34.0	53.8
14	S2Q2F2	128.10	25.00	46.90	121.6	27.0	51.4
15	S2Q2F3	138.30	17.00	44.70	124.4	23.6	52.0

No	Combination of Variable	Sample A			Sample B		
		K	M	T	K	M	T
16	S2Q3F1	126.07	28.03	45.90	123.3	29.9	46.8
17	S2Q3F2	134.90	20.30	44.80	129.5	25.0	45.5
18	S2Q3F3	144.87	15.10	40.03	135.8	21.1	43.1
19	S3Q1F1	115.40	31.70	52.90	112.4	34.5	53.2
20	S3Q1F2	122.27	28.17	49.56	118.9	26.0	55.1
21	S3Q1F3	133.67	17.60	48.70	125.5	23.5	51.0
22	S3Q2F1	127.87	27.40	44.73	118.3	30.7	51.0
23	S3Q2F2	136.20	21.00	42.80	127.2	24.0	48.8
24	S3Q2F3	144.37	14.20	41.40	134.7	20.7	44.0
25	S3Q3F1	134.10	23.03	42.87	128.9	27.3	43.8
26	S3Q3F2	142.00	18.03	39.97	133.9	23.3	42.9
27	S3Q3F3	150.07	12.03	37.90	140.3	18.2	41.5

Table 2. Recovery results on the shaking table experiment.

No	Combination of Variable	Recovery	
		Sample A	Sample B
1	S1Q1F1	50.20	49.98
2	S1Q1F2	55.23	52.55
3	S1Q1F3	59.45	55.93
4	S1Q2F1	54.23	53.65
5	S1Q2F2	61.03	57.05
6	S1Q2F3	66.03	60.45
7	S1Q3F1	59.03	57.50
8	S1Q3F2	63.70	60.13
9	S1Q3F3	69.08	63.23
10	S2Q1F1	53.25	52.15
11	S2Q1F2	57.17	54.63
12	S2Q1F3	61.43	58.48
13	S2Q2F1	58.05	56.10
14	S2Q2F2	64.03	60.80
15	S2Q2F3	69.15	62.20
16	S2Q3F1	63.03	61.50
17	S2Q3F2	67.45	64.75
18	S2Q3F3	72.43	67.93
19	S3Q1F1	57.7	56.18
20	S3Q1F2	61.13	59.43
21	S3Q1F3	66.83	62.73
22	S3Q2F1	63.93	59.15
23	S3Q2F2	68.1	63.6
24	S3Q2F3	72.18	67.33
25	S3Q3F1	67.05	64.48
26	S3Q3F2	71	66.93
27	S3Q3F3	75.03	70.15

Based on the analysis in table 1 and table 2, the highest concentrate weight of samples A and B was obtained from the combination of S3Q3F3 with a value of 150.07 grams and 140.3 grams. The combination S3Q3F3 is set at a slope of 8, the water flow rate is 15 L/min and the feeding speed is 15 minutes. While the lowest concentration results were obtained from the combination of S1Q1F1 which was at a slope of 4, water flow rate was 10 L/minute and the speed of feeding was 5 minutes.

Experimental activities were carried out to determine the performance or function of the shaking table. The experiment was designed with various combinations of variables, namely: deck slope (4°, 6° and 8°), debit 10 liters/minute, 12 liters/minute and 15 liters/minute. and variations in speed of 5, 10 and 15 minutes, the results are as follows:
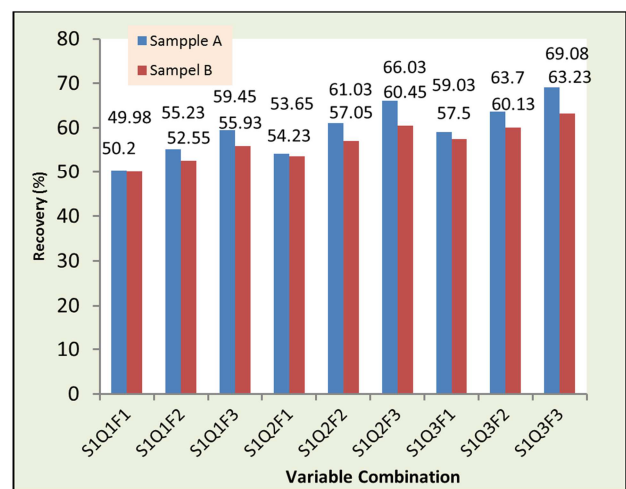
a. Effect of 4° Slope on Recovery

Figure 7. Graph of the recovery results of Sample A and Sample B at a slope of 4°.
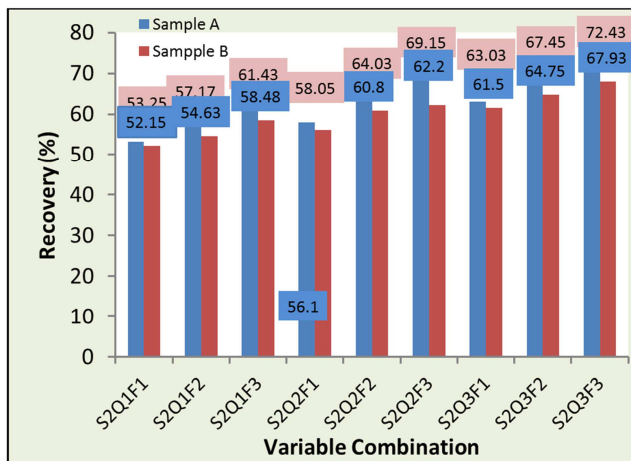
b. Effect of 6° Slope on Recovery

Figure 8. *Graph of the recovery results of Sample A and Sample B at a slope of 6°.*
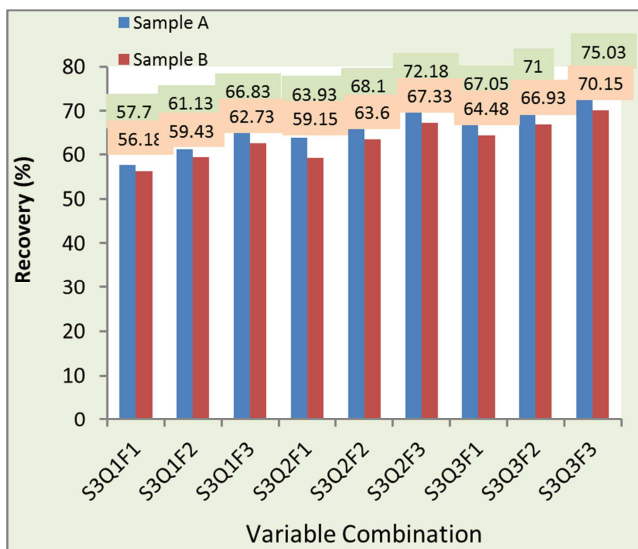
c. Effect of 8° Slope on Recovery

Figure 9. *Graph of the recovery results of Sample A and Sample B at a slope of 8°.*

From the experimental results with the shaking table in figure 7, 8 and 9, it shows that the optimum condition for sample A from the Bantam B122 Collecting Station was obtained in the combination of variables S3Q3F3. The optimum condition was achieved at a deck slope of 8°, water flow rate of 15 liter/minute and a sample feed rate of 15 minutes with a recovery of 75.03%.

Meanwhile, the optimum conditions for sample B taken from the TKT DU1522 Jangkang Washing Plant were achieved at the S3Q3F3 condition. obtained at a deck slope of 8°, a water flow rate of 15 liters/minute and a sample feed speed of 15 minutes of 70.15%. Both samples reached optimum conditions on the same combination of variables. This is influenced by the grain size of the two samples which are almost the same.

4. Conclusions and Suggestions

4.1. Conclusion

From the results of the description and analysis it can be concluded as follows:

a. The design of the shaking table with the Wiffley type starts from the study and measurement and analysis to the manufacture of a table/deck made of wooden boards/plywood. Then the table / deck is coated with good quality rubber (having a high level of resistance to water abrasion and friction), the type of rubber as the base for EPDM rubber sheeting (8 mm). Then the Riffle is installed parallel to the surface of the deck with a height of 3 mm, a width of 1 cm and a spacing of 3 cm.

b. The engine head (head motion) is measured and designed according to the capacity and power to move the table/deck. The electric motor that is installed to run the shaking table is a machine with a Siemen three-phase induction motortype C122M-4. The resulting speed of this type of motor is 1440 rpm. This motorized machine has the power to move the table with a power system through a pulley system so that it will move with a stroke length of less than 5 cm and a number of strokes of 140 strokes per minute with a motor power of 5 HP and a voltage of 220/380 V (3 phases).

c. From the results of the experiment, it was carried out by adjusting the shaking table variable (the rocking table tested was the slope of the deck, water flow and feeding speed. Each variable was tested with three variations so that each combination resulted in 27 variations of the combination. The highest recovery was obtained for sample A which derived from the Bantam B122 Collecting Station obtained on the combination of variables S3Q3F3. The optimum condition was achieved at a deck slope of 8, water flow rate 15 L/minute and a feeding speed of 15 minutes with a recovery of 75.03%. While the optimum conditions for sample B were taken from the Washing Plant TKT DU1522 The anchor is reached at the S3Q3F3 condition. The recovery results are obtained at a deck slope of 8, a water flow rate of 15 L/minute and a feeding speed of 70.15% for 15 minutes.

4.2. Suggestion

Based on the conclusions that have been obtained, the authors can suggest the following: 1. The performance of the shaking table in this study has not yet reached the optimum point. Therefore, further research can be carried out by changing the main components of the tool so that it can produce an optimal combination. tailings.

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