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Design of Air Table Equipment for the Separation of Metal Minerals by Gravity Concentration with Wind Media

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Abstract: This research is an air table device design and laboratory scale experimentation. Air table is a tool to separate valuable minerals from mineral impurities of tin ore based on differences in specific gravity, shape and size using air/wind media. The design of the tool starts from the design and manufacture of the table as well as the manufacture of other main components, including; feed hopper, ventilation and tertoron cloth. Then the next stage is the calculation and selection of a table driving motor in the form of an electric motor with a pulley system and the last is the calculation and selection of a blower machine as a machine that functions to blow pressure into the table. The installation of the air table was carried out at the Materials Processing Laboratory, Faculty of Engineering, Sriwijaya University. To determine the success rate of designing and evaluating the performance of the air table, experiments were carried out using several combinations of variables, including table slope, feed weight (grams), and processing time (minutes).). The experimental process of the tool was tested using tin ore samples from the remaining tin ore washing (SHP) from the Toboali Washing Plant, PT Timah, Tbk. The experimental results show that the performance of the tool shows good but not optimal performance where the lowest concentrate gain is achieved at 50.20% and the highest is 79.14% at a deck slope of 5.8°, feed weight is 600 grams and processing time is 15 minutes. The results of the evaluation show that the air table device functions relatively well, but needs to be improved and adjusted for more varied variables as well as representative samples and quantities of tin ore, so as to produce maximum concentrate and grade.

Keywords: Air Table, Deck, Head Motion, Blower Machine

1. Introduction

Metallic minerals have a significant difference in specific gravity with impurities, so they are processed using the gravity concentration method. Gravity concentration is a separation process that utilizes differences in the specific gravity of mineral components to obtain and recover one or more valuable minerals of economic value using certain technologies based on the physical properties of certain minerals [4]. The air table is the concentration of minerals based on the concentration of gravity. Air Table is a tool used to separate valuable minerals from impurity minerals based on differences in specific gravity, shape and size using air media [5].

This tool is in the form of a table that is mechanically driven using an electrically driven motor with a pulley system that provides a certain length and number of strokes so that particles can move in the direction of the blow. And this tool is equipped with an air blower machine that is installed under the table to blow air pressure onto the table [6]. The separation process for the air table is carried out using a dry process and the resulting products are concentrate, middling and tailings. A table that has a porous surface and has a two-way slope. The slope can be adjusted to allow the movement of particles in a vertical direction which creates pressure towards the porous table so that the particles will be ejected according to their specific gravity, shape and size [9].

Basically the principle of separating the air table is almost the same as the rocking table. The main difference between these two devices lies in the fluid that separates them. In the air table, compressed air is used as the separator fluid, so the

separation process must be carried out in dry conditions. While in the shaking table, the separating fluid uses water flow [10].

The forces acting on the air table are the gravitational force, the frictional force and the pushing force of the media (influenced by the air exhaled on the table). Furthermore, the minerals are spread and separated because they are influenced by the three forces above caused by the slope of the table and the difference in the speed of the back and forth step of the table [2].

The separation of fine tin ore is caused by the back and forth movement of the deck table which is driven by a head motion which is called the stroke length. The length of the blow and the air pressure from the blower machine will affect the separation between heavy minerals and light minerals. The back and forth movement of the deck table in such a way will cause 3 mineral separation zones, where heavy minerals will move to the concentrate zone and middling minerals to the middling zone and impurity minerals will go to the tailings zone [1]. The slope of the table deck is regulated and is a factor that affects the movement of minerals on the deck. The separation of heavy minerals and light minerals is greatly influenced not only by the slope of the deck, the processing time is also influenced by the mass of the feed. The determination of the table slope is based on the desired capacity and product [11].

The exhaled air stream reduces the frictional force between the particles and the table surface; The table top is made of scattered tertoron 2000. On the same surface, the lighter and finer the particles, the greater the friction reduction. As with any other treatment equipment, the feed size hose is an important factor in the success of the separation process [12].

In addition to the specific gravity (BJ) and grain size of minerals also affect the speed of movement of minerals in the separating medium. This is related to the value of the terminal velocity of the mineral in the separation medium [7].

The concentration criterion (COW) is an estimate of whether a gravity concentration process can be applied to separate minerals of different specific gravity and size ranges that can be used and in particular to assess the degree of difficulty of separation. KK is the relationship between the specific gravity of heavy minerals, impurities, and air/wind pressure used for separation [3].

The effect of specific gravity and grain size on recovery in the gravity concentration method of various minerals such as cassiterite, quartz, ilmenite, monazite and wolframite, the separation process can be carried out using an air table so that with increasing particle size, the concentrate yield will increase [8].

In an experiment to test the function of the Air Table device which is designed to test samples of tin ore from PT Timah, Tbk Bangka at the location of the leached tin ore collection station (SHP) in Toboali. The main mineral tin ore (cassiterite) is the main product of the washing process, where the water table is still the mainstay to separate the main mineral cassiterite tin ore from the quartz impurity mineral. In this test, the recovery of valuable minerals will be calculated by the percentage of impurity minerals. So from the results of this experiment it can be seen whether the trend line of the mineral separation scheme runs optimally. So that it will be evaluated so that the tool can function properly as a tool used to separate metal minerals with a concentration of gravity. The final result that is expected with the existence of this Air table tool, in addition to enriching the lecture material, can also be used for student practicum. In addition, it is hoped that it can be used for lecturer research and student final assignments with different combinations of variables.

2. Research Method

This research was conducted in April – December 2021. In the research on the design of the air table device, two important steps were carried out, namely the design and assembly of the Air Table device and experimentation activities with tin ore samples from PT. Timah, Tbk Bangka.

Design and modification activities as well as sample testing experiments 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 wind table was preceded by conducting an initial study of literature and comparative studies at the Tin Ore Washing Center of PT. Timah, Tbk, Bang Kabelitung Province. The study was to obtain a real picture of the conditions and identify problems with the air table device being studied.

The next activity is to observe and measure the capacity and strength of the air table by calculating and selecting a driving motor with an electric pulley system so that the table can move with a certain length and number of strokes.

The sample used in the experimental design of the air table is tin ore. The samples used as materials were taken from the location of the PT Timah Tbk Washing Plant. Sampling was carried out at the location, namely samples of tin ore from washing residue (SHP) at the Toboali Washing Plant Collecting Station belonging to PT. Timah, Tbk. as much as 60 kg Sampling was carried out by taking samples of tin in the pile using an auger drill on three sides of the top pile, left and right side as many as 10 sample points.

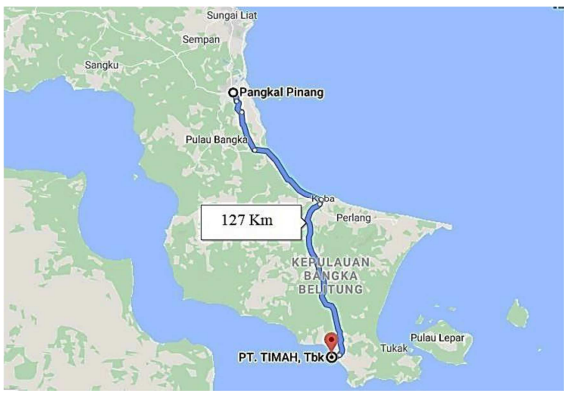


Figure 1. *Location Sampling Washing Plant Toboali PT Timah Tbk Bangka Belitung Province.*

Figure 2. *Research activities for tin ore sampling.*

The stages of the research can be described as follows:

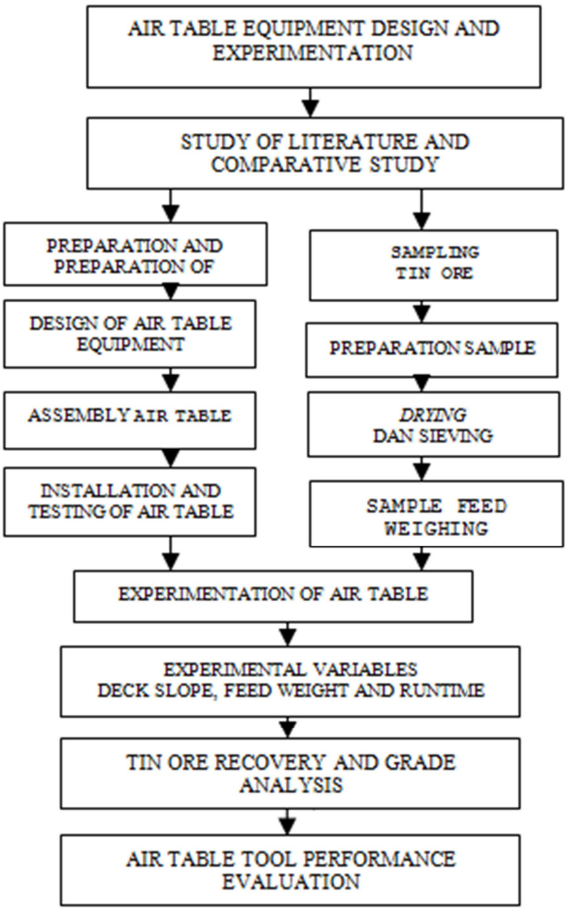


Figure 3. *Research Flowchart.*

3. Results and Discussion

In this research, it is divided into two major stages, namely Phase I, design, assembly and installation of Air Table Equipment/Technology (wind table) and Phase II is an experimental activity, namely experimental testing of laboratory-scale ore samples from PT Timah Tbk Bangka, with the variables used are slope and feed rate of the feed.

The table / deck design activity was carried out at the Mineral Processing Laboratory in Inderalaya and measurements and machine installation were carried out at a machine shop in Palembang. Experimental activities were carried out at the Mineral Processing Laboratory, Indraalaya Campus, Sriwijaya University. The stages and important parts of the design and installation can be described in the technical description below:

3.1. Deck of Table Design Results

In the initial design activity, the manufacture of the table / deck was carried out through 4 stages and important parts, namely:

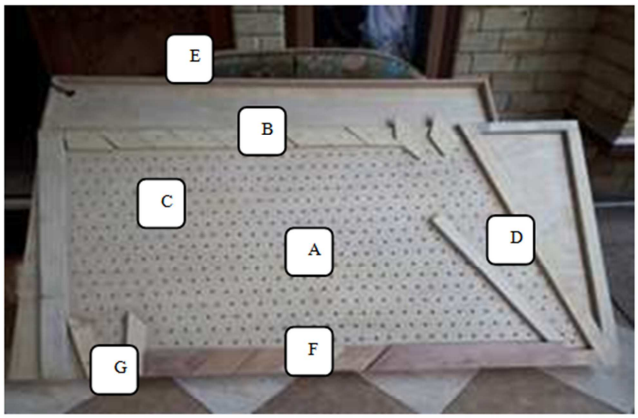
3.1.1. Deck of Table

The table deck is designed and made using quality hard plywood as the base material. The type of wood used is quality A hard plywood with a thickness of 12 mm. The selection of this type of hard plywood is seen from its advantages with high abrasion resistance properties. Table of deck is designed with length and width: 190 cm x 90 cm.

3.1.2. Table Hole

The hole in the air table serves as a medium for the entry of air exhaled by the blower machine. The table holes are spread across the table surface with an average hole diameter of 7 mm.

The wind or air pressure that will be blown from the blower to the table surface through the hole and through the Tertoron 2000 type cloth that has been affixed to the entire table / deck surface. Due to the air pressure from the blower, the minerals on the table surface will experience movement and separate according to their specific gravity, where the heavy ones will rise to the top and the lighter ones will go down to the tailing lounder and middling.



A. Table / Deck
B. Lounder
C. Hole / hole
D. Splitter Feed
E. Concentrate Splitter
F. Splitter Middling
G. Splitter Tailings

Figure 4. *Results of table design with length and width: 190 cm x 90 cm.*

3.1.3. Splitter

The splitter is made using wood/plywood with a thickness of 3 cm and w: 5 cm x 15 cm. The position of the riffle/bulkhead is made on the surface of the table/table and is placed in 4 main parts, namely: bulkhead 1 to adjust the feed/sample rate from the hopper, bulkhead 2 to regulate the concentration of concentrate on the table, and filters 3 and 4 at the bottom to regulate the rate. tailings mass and

intermediate mass. The dimensions of the bulkhead/gun are 3 cm thick, 15 cm long and 10 cm wide. The installation of the riffle on the deck is arranged with an open and close system in accordance with conditions when mineral separation (ore separation) is normal/good.

3.1.4. Lounder

The loader or container of concentration results is divided into 3 parts, the top and the bottom. Tailings and middling washes are installed at the bottom and bottom end of the table. Concentrate washers are installed at the top end, and each washer has an opening/gate for dropping the concentration result.

3.1.5. Hopper Feeding

Hopper serves to adjust the sample feed that goes into the deck. The hopper is placed on the table in the top position so that the bait can be adjusted for speed and mass. The hopper is made of a thin plate with a diameter of 25 cm and a length of 40 cm. Under the hopper, a control baffle is installed to adjust the sample rate so that the movement of the sample can be controlled according to specific gravity and size. The above sample will experience movement in the separation center regularly according to differences in density, shape and size. After the process of time the mineral mass will move towards concentrates, middling and tailings.

3.1.6. Blower Machine

Blower is an important part of the air table tool to blow air with a certain pressure with a blower power capacity of 550 watts, electrified with a voltage of 220 volts, pressure: 600 Pascal, 2.8 Ampere, load speed: 3000 RPM and output diameter: 102 mm (4 inches).

Figure 5. *Blower machine.*

The blower will be placed under the table / deck, with a closed system, the blower will provide air pressure from below through the hole / hole in the table / deck so that it can spill minerals on the table surface.

3.2. Stages and Results of Machine Design (Head Motion)

The driving machine (head motion) functions to move the table / deck that has been designed with a measured power. The electric motor installed to run the air table is a machine with a three-phase induction motor type 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 stride length of less than 5 cm and a number of steps of 140 steps per minute with a motor power of 5 Hp and a voltage of 220/380 V (3 phases).

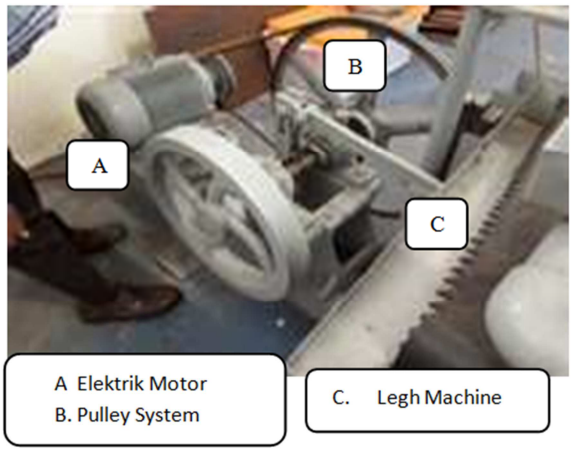


Figure 6. *Driven system air table electric motor pulley system.*

3.3. The Air Table Tool Designed at the Minerals Processing Laboratory

The results of the design and assembly of the Air Table tool as shown in Figure 7 are already systemized and ready to function.

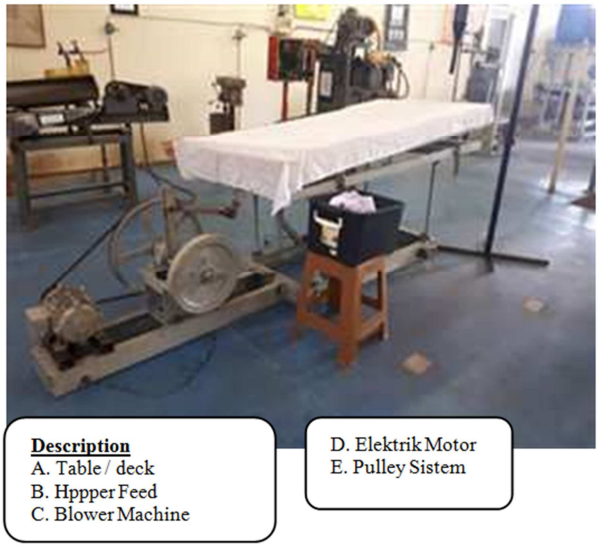


Figure 7. *The result of air table design tool.*

In addition to the table / deck and driving machine, this tool is equipped with 4 main components, namely: (1) table / deck, (2) engine, (3) hopper and divider feeding system (4) blower machine.

3.4. Results of Experimentation of the Air Table

The experiment aims to make the tool work well or not, so that it will be used as an evaluation material so that later the air table tool can work optimally. In the experiment, the sample used was refined tin ore from the washing plant to

boali from PT Timah Tbk. A total of 60 Kg.

Then the samples were cleaned and dried. The clean and dry samples were filtered using a sieve shaker to determine the size distribution. The results of the sieving analysis obtained a sample size distribution of 30 mesh to 100 mesh.

In the experimental test of tin ore, the main variables used are:

1) The sample used for the sample is dried and has been sieved 50 mesh and 100 mesh sample sizes.
2) Slope of deck: 5,6°, 5.8° and 6,1°.
3) Sample feed weight of 300 gr 500 gr and 600 gr.
4) The trial process time is: 15 minutes, 20 minutes and 30 minutes.
5) Each variable was tested for 3 variations so that each combination resulted in 27 variations of the combination.

Determination and setting the slope of the deck is carried out before each experiment is carried out to obtain recovery from each experiment. The formulation of the deck slope according to J. Wills will affect the movement of particles according to their characteristics, namely specific gravity, shape and size of the particles.

$$F = m.\ g.\ Cos\alpha$$

Where:
F= thrust
m = mass of feed / weight of feed (kg)
g= gravitational force (9.8 kg m per second²)
Standard slope of deck = 1° - 5° (J. Wills, 2012)

Other variables from this study besides deck slope are air pressure from the blower machine, hole diameter, stroke length and number of stroke lengths per minute (RPM). Each variable was tested for three variations so that each combination resulted in 6 variations of the combination. The success of the separation can be seen from the concentration recovery value obtained.

From the experimental results of the variation in the combination of deck tilt variables (5.6°, 5.8° and 6.1°), the following results are obtained:

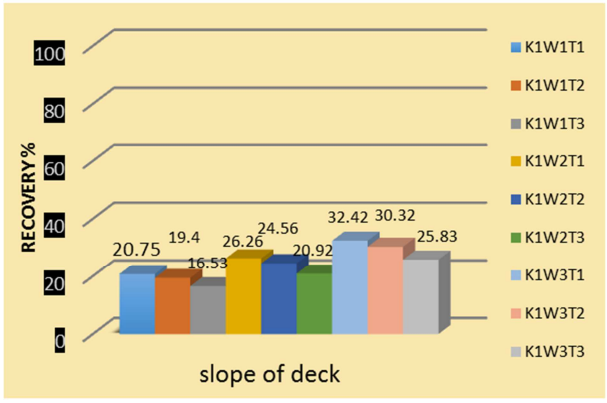


Figure 8. *Graph of comparison of feed variations with recovery at a slope of deck 5,6°.*

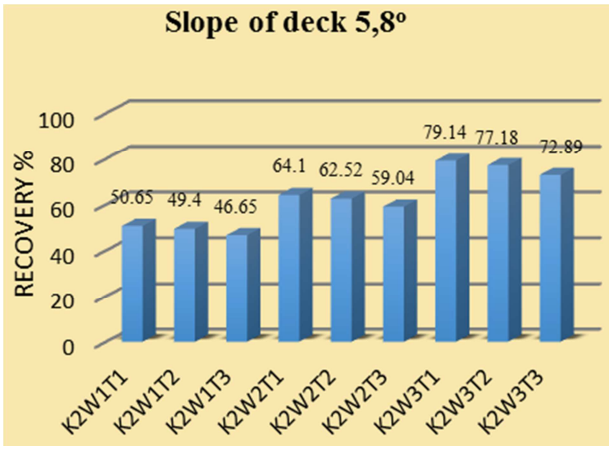


Figure 9. *Graph of comparison of feed variations with recovery at a slope of deck 5,8°.*

Table 1. *Experimentation Results at a Slope of Deck 5,6°.*

Kemiringan DeckK (°)	Berat Sampe lW (Gram)	Waktu T (menit)	Kombinasi variable	Recovery (%)
		15	K1W1T1	20,75
	300	20	K1W1T2	19,40
		30	K1W1T3	16,53
		15	K1W2T1	26,26
5,6°	500	20	K1W2T2	24,56
		30	K1W2T3	20,92
		15	K1W3T1	32,42
	600	20	K1W3T2	30,32
		30	K1W3T3	25,83

Table 2. *Experimentation Results at a Slope of Deck 5.8°.*

Kemiringan Deck K (°)	Berat Sampel W (Gram)	Waktu T (menit)	Kombinasi variable	Recovery (%)
		15	K2W1T1	50,65
	300	20	K2W1T2	49,40
		30	K2W1T3	46,65
		15	K2W2T1	64,10
5,8°	500	20	K2W2T2	62,52
		30	K2W2T3	59,04
		15	K2W3T1	77,18
	600	20	K2W3T2	79,14
		30	K2W3T3	72,89

Table 3. *Experimentation Results at a Slope of Deck6,1°.*

Kemiringan Deck K (°)	Berat Sampel W (Gram)	Waktu T (menit)	Kombinasi variable	Recovery (%)
6,1°	300	15	K3W1T1	43,19
		20	K3W1T2	42,07
		30	K3W1T3	40,75
	500	15	K3W2T1	54,66
		20	K3W2T2	53,25
		30	K3W2T3	51,57
	600	15	K3W3T1	67,49
		20	K3W3T2	65,74
		30	K3W3T3	63,67

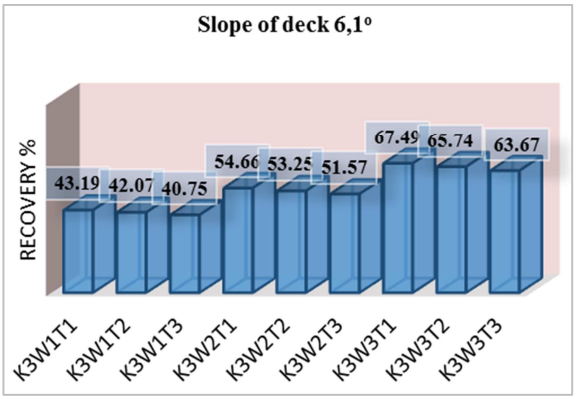


Figure 10. *Graph of comparison of feed variations with recovery at a slope of 6,1°.*

3.5. Effect of Deck Slope on Recovery

The magnitude of the effect of deck slope on recovery was determined by non-linear regression analysis using quadratic polynomial method, so that the quadratic regression function was obtained, namely $\hat{Y} = 3588{,}71 + (-1208{,}734) + 103{,}878\ X^2$.

The coefficient of determination (R^2) needs to be calculated to find out how much influence the independent variable has on the dependent variable simultaneously. From the calculation of the coefficient of determination, the value (R^2) is 0.030, meaning that the slope of the deck on the air table has an effect of 3% on recovery. The influence relationship between the deck slope and recovery variables can be seen in Figure 11.

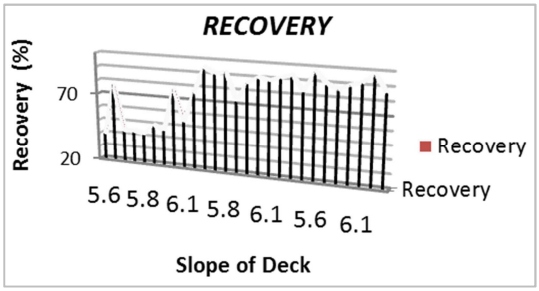


Figure 11. *Effect of deck slope on recovery.*

4. Conclusions and Recommendations

4.1. Conclusion

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

1) The design of the air table tool is based on the planned design starting from the manufacture of the table / deck (190 cm x 90 cm) to the manufacture of other supporting tools such as: 6 mm diameter holes, concentrate feed splitter bulkhead, middling and tailings. The finished table / deck will then be installed with tertoron 2000 cloth on the table surface.
2) The construction of the driving machine (head motion) uses an electric motor type Siemen 3 HP (1450 RPM) pulley system to drive a table with a punch length (5 mm - 1.5 cm) with a number of strokes of 140 PP / minute to 150 PP / minute. Construction Machinery Drive This will be attached to the table with the calculation (precision) of the table right above the construction. Then the blower machine, a tool to blow air vertically with a pressure of 600 Pa, output 102 mm is installed under the table with a distance of 50 cm.
3) From the experimental results for tin ore samples using the Air Table (dry process) tool from the Belinyu Collection Station of PT Timah, Tbk Bangka. The process variable for the air table tool includes the slope of the deck, (5.6°, 5,8° and 6.1°.) The lowest recovery is 20, 75% in the first experiment on the combination of variables K1W1T1 (5,6°, 300 gr and 15 minutes).

While the highest recovery was obtained in Experiment 3 at 79, 14% with the combination of the K1W3T2 variable. Reached on a slope of deck of 5,8, Feed Mass of 600 grams and processing time of 20 minutes.

4.2. Recommendations

a) The performance of the air tablein this study has not reached its optimum point. Therefore, further research can be carried out by changing the main components of the tool so that it can produce the optimal combination.
b) Further research can be modified by changing the air pressure of the blower engine and the length of the blows and the number of blows per minute in order to increase the thrust of minerals to maneuver / movement and the possibility of being carried away and separated to form a concentrate zone, middling and tailings zone.

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