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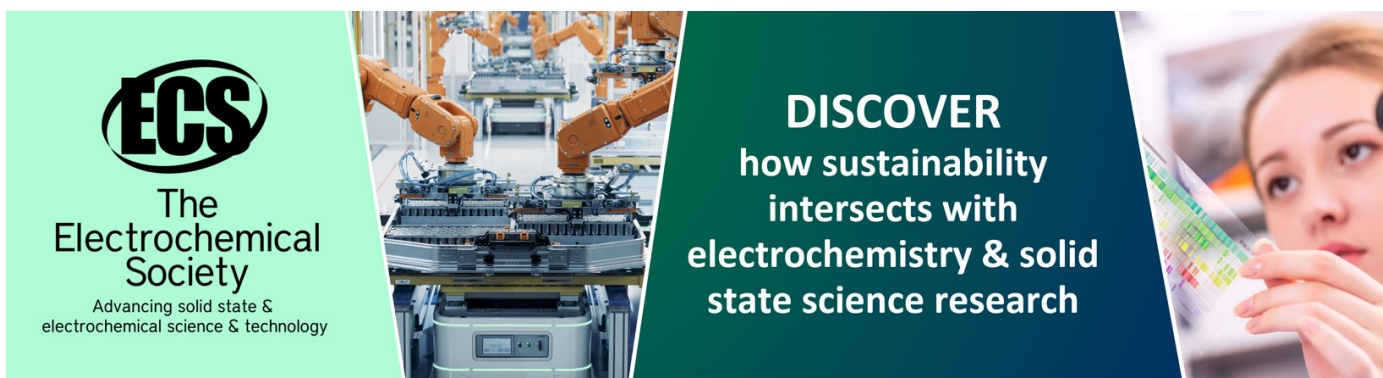
## Separation the zircon mineral from tailing Tin mining using shaking table

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# Separation the zircon mineral from tailing Tin mining using shaking table

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**Abstract.** Separation the zircon mineral from tailing tin mining using a shaking table. Zircon mineral has been separated from the Bangka Belitung tin mine tailings by shaking table. The process stage begins with draining the water until the flow is in a stable state, followed by loading the material through the feeder. The results of the process in the form of concentrate were dried in the oven at 105 °C. This research studied the effects of water discharge, feed rate, and the tilt angle of the shaking table. The results obtained were the optimum water discharge at 17 liters per minute, the feed rate was 15 kg per minute with a tilt angle of the shaking table was 10 °. In these conditions, the recovery results obtained were 88.80 %.

## 1. Introduction

The history of research and extractive industries in Indonesia has experienced an increase in technical mastery and adaptation by designing and building various mineral processing devices (smelters) such as tin. However, there are still a lot of potential mineral resources in Indonesia, the amount of which is quite large and spreading, which has not received attention for the increase in value-added especially zircon as a follow-up mineral. Increasing the value-added of Indonesian mineral resources is the beginning of the actual topic with the ratification of the Minister of Energy and Mineral Resources Regulation No. 05 of 2017 concerning Increasing the Added Value of Minerals through Domestic Mineral Management and Refining Activities. By-products or residues from the processing of Mineral mining commodities Tin metal in the form of zircon, ilmenite, rutile, monazite, and xenotime concentrates must be processed and/or refined in the country in accordance with the minimum limits of processing and or refining of Mineral mining commodities. Metals and nonmetallic minerals [1].

**Table 1.** Mineral composition [% w] of selected representative tailing samples [2]<sup>1</sup>.

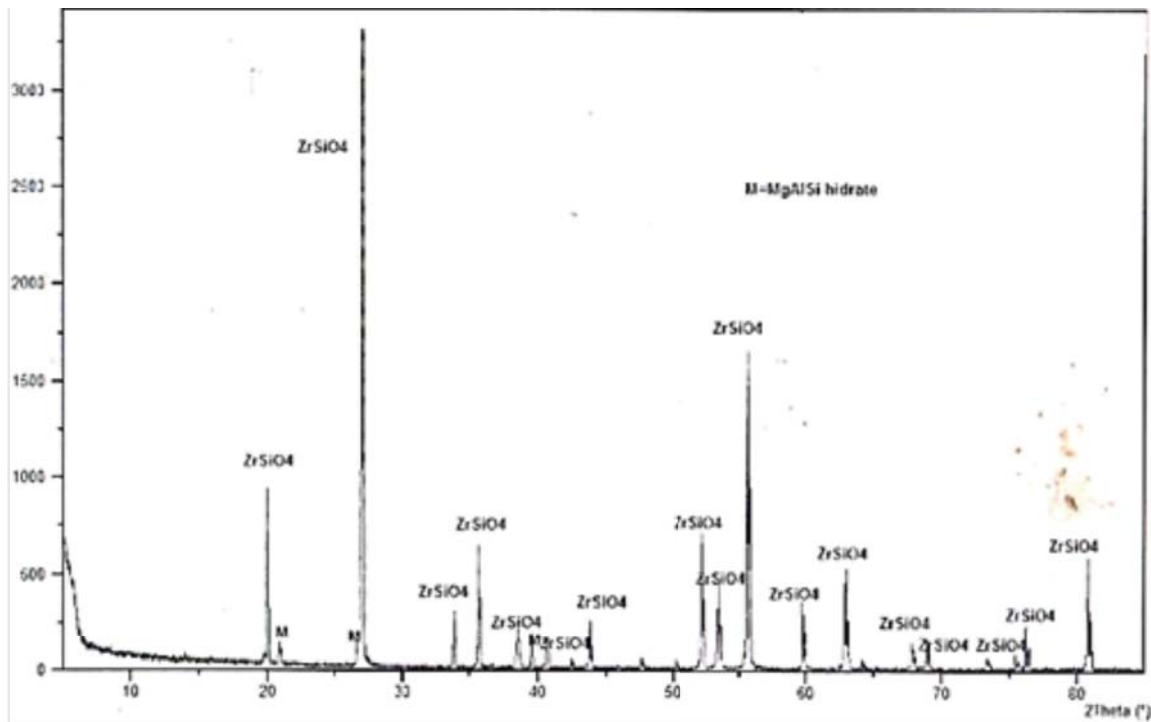
| Mineral   | Chemical properties    | Spesific gravity | Hardness | Electrical properties | Magnetism    |
|-----------|------------------------|------------------|----------|-----------------------|--------------|
| Kasiterit | Sn<br>O <sub>2</sub>   | 6 – 7            | 6,<br>5  | Conductor             | Non Magnetic |
| Ilmenit   | FeTi<br>O <sub>2</sub> | 4,5 – 5          | 6        | Conductor             | Magnetic     |
| Monasit   | (Ce, La, Y,<br>Th)     | 4,6 – 5,4        | 5        | Non Conductor         | Magnetic     |
| Zirkon    | ZrSi<br>O <sub>4</sub> | 4,2– 4,7         | 7,<br>5  | Non Conductor         | Non Magnetic |



|                |                                                                                        |           |       |               |              |
|----------------|----------------------------------------------------------------------------------------|-----------|-------|---------------|--------------|
| Senotim        | Y(PO <sub>4</sub> )                                                                    | 4,4 – 5,1 | 4 – 5 | Non Conductor | Magnetic     |
| Pirit/Markasit | FeS <sub>2</sub>                                                                       | 5         | 6, 5  | Conductor     | Non Magnetic |
| Rutil          | TiO <sub>2</sub>                                                                       | 4,2 – 4,3 | 6, 5  | Conductor     | Non Magnetic |
| Topas          | (AlF) <sub>2</sub> .SiO <sub>4</sub>                                                   | 3,5 – 3,6 | 8     | Non Conductor | Non Magnetic |
| Tourmalin      | HgAl <sub>3</sub> (BO <sub>3</sub> H) <sub>2</sub>                                     | 3,0 – 3,2 | 7, 5  | Non Conductor | Magnetic     |
| Kuarsa         | Si                                                                                     | 2,65      | 7     | Non Konduktor | Non Magnetic |
| Anatas         | TiO <sub>2</sub>                                                                       | 3,9       |       | Conductor     | Non Magnetic |
| Spinel         | MgOAl <sub>2</sub> O <sub>3</sub>                                                      | 3,6       |       | Conductor     | Non Magnetic |
| Siderit        | FeCO <sub>3</sub>                                                                      | 3,8 – 4   | 4     | Non Conductor | Magnetic     |
| Plumbogumite   | PbAl <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> (OH) <sub>5</sub> (H <sub>2</sub> O) | 7,5       |       | Non Conductor | Non Magnetic |
| Limonite       | 2Fe <sub>2</sub> O <sub>3</sub> .3H <sub>2</sub> O                                     | 3,6 – 4,0 |       | Non Conductor | Magnetic     |

Zircon minerals, if further processed, have a very strategic role in various industries. In the nuclear industry, this material can be applied as a raw material for making oxygen sensors, because has the nature of flexibility, and high corrosion resistance. Oxygen sensors are devices that industry as an opacifier, refractory, alloy, glass TV, zirconia and zircon chemicals<sup>[3]</sup>.ear systems such as the LFR (Lead alloy-cooled Fast Reactor) or target spallation on the ADS (Accelerator Driven System). While the applications in the non-nuclear industry are divided into six major groups namely the ceramic are often called Zircosil or Micronized Powders for the Ceramics Industry or Micronized<sup>[4]</sup>.

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**Figure 1.** Diffractogram zircon sand

Zircon is a follow-up mineral from tin or gold ore and as a mining material that is classified as class B minerals because zircon is one of the vital minerals. The zircon content contained in this sand is low (marginal) between 35-50%, as a result, it is less efficient, so it is necessary to increase levels (beneficiation)<sup>[5]</sup>. The beneficiation device that is often used is the shaking table.



**Figure 2.** Shaking table

Shaking tables was a mineral separator devices that work based on different physical properties in flowing water media. This device is equipped with a Motion head, Stroke regulator, table, riffle, drive motor, feed box, washing water box, concentrate container, middling and tailings. Riffle functions to form turbulence in the flow of water, so that light particles get a chance to be above and heavy particles relatively below. The consequence is that light particles will be pushed or carried faster than heavy particles in the direction of water flow<sup>[6]</sup>. The movement of particles in a liquid can be determined using the equation:

$$m \frac{dx}{dt} = mg - m'g - D \quad (1)$$

Where :

$m$  = grain mass of minerals

$dx / dt$  = acceleration

$g$  = acceleration due to gravity

$D$  = fluid resistance to particle displacement

The position of the riffle is divided into 3 zones:

- Zone stratification
- Clening zone
- Dischange zone

Factors that influence flow movement (flowing film concentration)<sup>[7]</sup>, namely:

- Slope deck.  
On a horizontal deck, there will be no movement of particles. Particles will start rolling when the plane has a tilt angle. The inclination angle of the table also determines the speed at which the concentrate is rolling and the tailings are carried along with the turbulent flow.
- Thickness or speed of the water.  
Water that is flowed into the rocking table, will produce a thrust against the material that flows with it.
- Fluid viscosity  
The more liquid the fluid is used, the better the product will be produced, whereas in the thick fluid there will be a mixture between the concentrate and the tailings.
- Particle shape  
Spherical particles will be more quickly separated when compared with material that is flat or irregular in shape.
- Specific gravity of material or particles  
Specific gravity will determine the accuracy of separation between particles. If the material between the concentrate and the tailings has a specific gravity linkage, the concentrate and tailings particles are very easily separated. According to Wills, separation based on specific gravity in the media is determined by equation<sup>[8]</sup>

$$CC = (p_h - p_f) / (p_l - p_f) \quad (2)$$

where:

$CC$  = Concentration criterion

$p_h$  = specific gravity of heavy mineral

$p_l$  = specific gravity of light minerals

$p_f$  = specific gravity of the medium

- Hardness of deck surface  
Deck surface hardness affects the size of the frictional force produced between the particles of the particle with the deck surface, the smaller the frictional force received.
- Collision coefficient between particles.  
The magnitude of the coefficient of friction between particles is enough to determine the speed of the separation process, where material having a larger size tends to fall near the flow and hold in the uppermost riffle, while particles of size will be thrown due to collisions between particles and carried along with turbulent water flow. According to Stokes, the frictional force can be represented by the equation:

$$F_s = 6 \pi r \mu v \quad (3)$$

Where :

$F_s$  = friction (N)

$r$  = Object radius (m)

$\mu$  = coefficient of viscosity (kg / ms)

$v$  = speed of fall in fluid (m / s)

This research was studied the effect of discharge, slope angle and feed speed on the recovery of the beneficiation process using a shaking table.

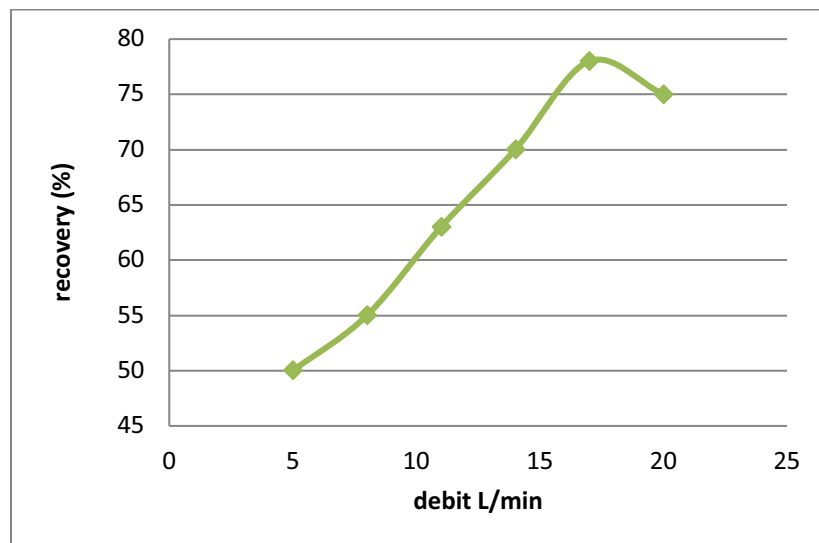
## 2. Methodology

**Material used:** The by-product of tin mining (zircon sand) with a  $ZrO_2$  content of 55.87% is used as raw material. **Water** is used as a separation medium using a shaking table. **Tools used:** A set of shaking table as a mineral separation device that is equipped with a Motion head, Stroke regulator, table, riffle, drive motor, feed box, washing water box, concentrate container, middling and tailings. Scales are used to weigh raw materials and the results of separation.

The shaking table is prepared, the motor driving the table (vibrator) and the motor regulating the feeder (feeder) is turned on. Water as a media flows and its speed is regulated. Weighed zircon sand as a feed and then put it in the feeder tank, then flowed and regulated. The results of the separation process (concentrate, medling and tailings) are taken. The concentrate obtained was dried using an oven at 105 for 5 hours. Experiments were carried out by varying the water discharge (10,12,14,16,18 and 20 liters per minute), feed speed (10.12, 14, 16.18 and 20 kg per minute) and the inclination angle of the table (3, 5, 7, 9, 11, 13, 15 and 17 degrees).

## 3. Results and Discussion

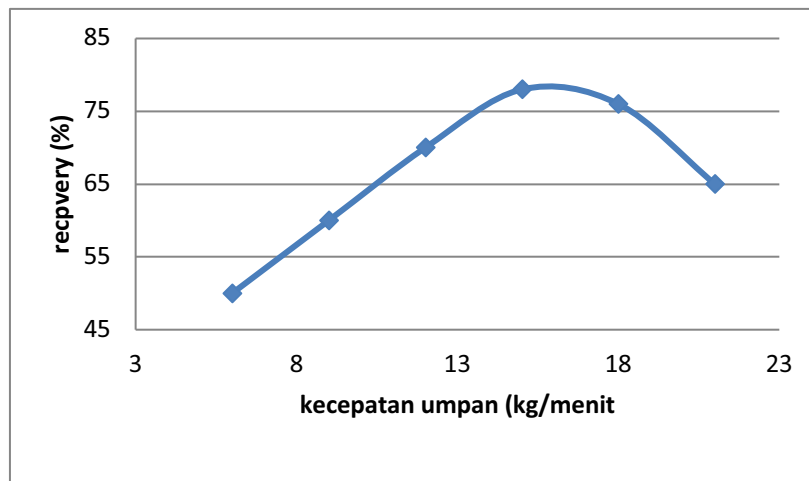
Zircon mineral extraction has been carried out from tin mining tailings using a shaking table device. The results of experiments using a shaking table device with variations in water discharge are presented in Figure 3.



**Figure 3.** Effect of the velocity of water flow (discharge) on zircon minerals extracted.

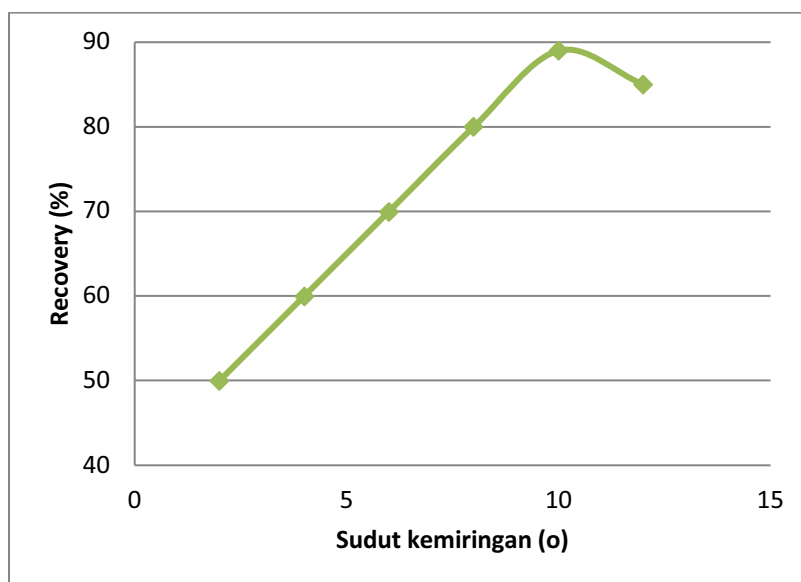
Figure 3. shows that the velocity of water flow (discharge) greatly influences the zircon mineral separation process from the feed. In figure 3 it appears, the faster the water discharge (5 L / min to 17 L / min) causes the amount of zircon minerals to increase significantly. This proves that the higher the water discharge will increase the thrust of the bait. The consequence is that the movement of the bait is faster and more irregular so that it hits the riffle further or detaches the light mineral from heavy minerals and is pushed into the tailings reservoir. However, when the discharge is continuously increased to 20 L / min, the amount of zircon minerals separated is no longer significant, this shows that the optimum water discharge is at 17 L / min.

The results of the study of the effect of feed rate on integral mineral recovery are presented in Figure 2.



**Figure 4.** Effect of the velocity of feed rate on zircon minerals extracted.

Figure 4. shows that the feed rate greatly influences the process of zircon mineral separation from the feed (tin mine tailings). In figure 3 it appears, the greater the feed rate (10 L / min to 18 L / min) results in separate zircon minerals increasing with increasing feed rate. This proves that the faster the feed rate will increase the feed transfer coefficient. The consequence is irregular moving bait, resulting in the erosion of light minerals from heavy minerals and being pushed into the tailings reservoir. However, when the discharge is continuously increased up to 20 L / min, the amount of zircon minerals is no longer significant, this shows that the optimum water discharge is at 18 L / min. The results of the study of the influence of the tilt table angle on the recovery of integral minerals are presented in Figure 5.



**Figure 5.** Effect of tilt table angel on zircon minerals extracted.

Figure 5. shows that the slope of the table angle greatly influences the separation process, this is evidenced that when the table angle is increased in size (3° to 18°), the resulting zircon minerals increase as the table angle increases (70 % to 88,80 %). This happens because the greater the angle of the table also causes the turbulence caused by the greater, so that light minerals are pushed into the tailings reservoir. However, when the discharge is continuously increased to 8 o, the amount of zircon minerals extracted is no longer significant and even tends to decrease, this shows that the optimum table angle is at 7°.

#### 4. Conclusion

Zircon mineral separation using a shaking table device were highly influenced by several variables. The results showed that the zircon mineral separation process from tin mine tailings used an optimum shaking table were at 18 L / min water discharge, 18 Kg / min, feed rate were 15 kg per minute and slope angle of 7°. In these conditions, the process recovery is achieved by 80%.

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