International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 10 – Issue 03 || May - Jun 2025 || PP. 11-18

# Performance Analysis of Rotary Type Zeolite Sand Sifter Machine with Varying Tilt Angle & Rotating Speed Variation

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**Abstract:** Sieving is the process of grouping particles that will be separated into one or more groups. One type of sand that requires a sieving process is zeolit sand. Sand sieving machines are divided into several types, one of which is the rotary type. This study aims to create the best performance of a rotary type zeolit sand sieving machine by determining the appropriate parameters for the variations in the angle of inclination and rotational speed of the sieving tube. The determined variations will affect the duration of the sieving process and the results of the zeolit sand sieving. The Taguchi method is used to optimize the variations through an $L_9$ $(3^2)$ orthogonal matrix. Based on the results of this study, the angle of inclination and rotational speed significantly affect the duration of the sieving process and the results of the zeolit sand sieving, with contribution percentages of 17,72% and 45,18% for the duration of the sieving process, and 39,33% and 33,45% for the sieving results. The highest sand sieving result was obtained with the variation of a 10° angle and 28 rpm, which resulted in 6,70 kg of fine zeolit sand with a time of 256,6 seconds, while the fastest sieving time was obtained with the variation of a 20° angle and 61 rpm, resulting in a sieving time of 198,3 seconds and 2,67 kg of fine sand. Therefore, the results of this study can serve as an alternative in selecting parameter variations for the zeolit sand sieving process using a rotary type sieving machine.

**Keywords:** sifter machine, rotary, zeolit sand, angle, speed.

## 1. Introduction:

Sieving is a process for grouping granules based on certain sizes, which aims to separate the granules into one or more. This process is also useful for separating coarse and fine particles, resulting in a more uniform particle size [1]. Over time, the sand sieving process which was previously carried out manually has now developed using a sieving machine [2]. In developing more efficient sand sieving machine technology, it is hoped that it can produce high quality sand while reducing labor costs [3]. One type of sand that usually requires a sieving process is zeolite sand.

Zeolite sand has an important role in reducing water requirements for plant growth in sand media. One study showed that variations in the amount of zeolite (15%, 30%, 45%) and zeolite size (50 mesh, 80 mesh, 100 mesh) had a significant impact on the water content in the sand media, with three repeated experiments. The higher the zeolite content, the more effective the sand media is in retaining water [4].

The choice of type of sieving machine also greatly influences the sieving results. One type of sieving machine that is often used is the rotary type. Several studies using rotary type sieving machines show that the rotation speed and tilt angle of the sand filter have an influence on the sieving process, where at an angle of 10° the sieve produces fine sand weighing 1,35 kg, coarse sand 1,97 kg, and very coarse sand 2,68 kg. This shows that the greater the angle of inclination used, the less sand will be filtered, due to the influence of gravity on the sand sieve tube. Meanwhile, the screening process with the fastest time efficiency produces 1,06 kg/s at an angle of 20° and rpm 50. This shows that the filtered sand is not separated well. Therefore, the rotation speed of the tube and the tilt angle of the sieve have a great influence on the flow rate of the filtered sand [5].

Using the correct tilt angle and rpm speed on the sieve machine can increase the length of sieving time and maximum sand sieve capacity. Therefore, the author tested a rotary type zeolite sand sieving machine using variations in tilt angles of 10°, 15°, and 20° and speeds of 28 rpm, 34 rpm, and 61 rpm. It is hoped that from this research, a sieving machine using a rotary mechanism can influence the speed of the sieving process and increase the results of zeolite sand sieving.

## 2. Materials and Methods:

In this study, an experimental method was used with the influence of varying tilt angles of 10°, 15°, and 20° and speeds of 28 rpm, 34 rpm, and 61 rpm. It is hoped that from this research, a sieving machine using a rotary mechanism can influence the speed of the sieving process and increase the results of zeolite sand sieving. The tool schematic can be seen in Figure 1.

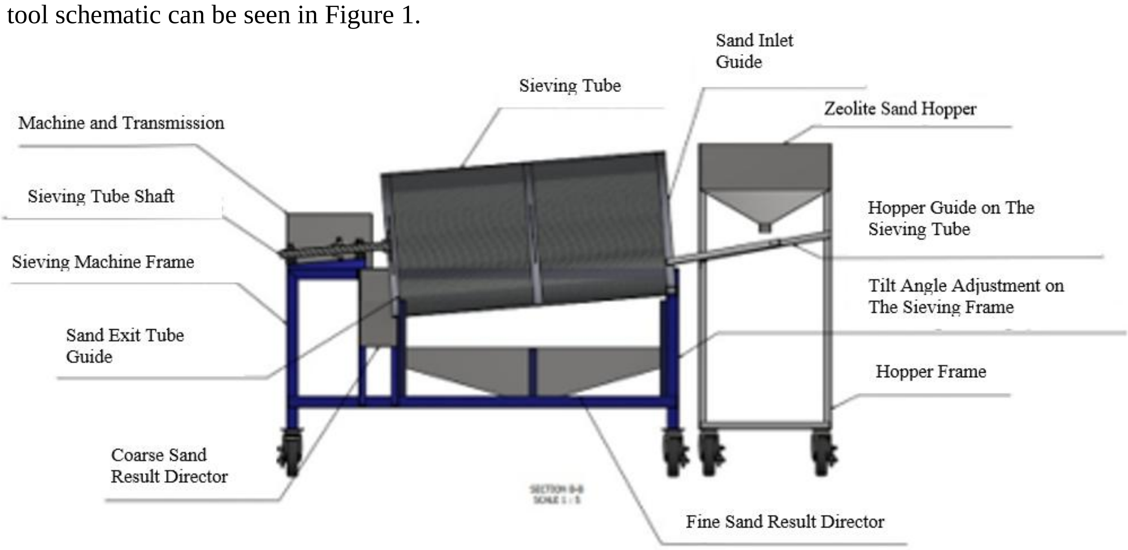


Figure 1: Sifter machine scheme

### 2.1. Data Retrieval

The process of sifting zeolite sand using a rotary type sieving machine can be shown in Figure 2. Briefly, the zeolite sand that has not been sifted is first measured according to the control variable, namely 25 kg, then poured the zeolite sand into the hopper of the sieving machine using the specified angle and rpm. determined on the independent variable, after that the process of calculating the length of the sieving process and weighing the weight of the results of the coarse and fine zeolite sand sieving process continues.


Figure 2: The schematics process of sifting zeolite sand.

### 2.2. Research Method

In this research, the Taguchi method is used, which is a design method needed to minimize variability and maximize quality in a measurable production or manufacturing process. The Taguchi method takes into account the effects of variations in factors that influence product quality, and optimizes quality target values with minimal production costs [6]. The use of an orthogonal matrix is intended to determine the minimum number of experiments as data that contains information about the factors that influence the parameters. The orthogonal matrix used is $L_9$ ($3^2$). The use of the orthogonal matrix $L_9$ ($3^2$) can be shown as in Table 1 below.

Table 1: Matrix Orthogonal $L_9$ ($3^2$).

| | Control Parameters | |
|---|---|---|
| Experiment | Tilt Angle (°) | Tube Speed (rpm) |
| 1. | 10 | 28 |
| 2. | 10 | 34 |
| 3. | 10 | 61 |
| 4. | 15 | 28 |
| 5. | 15 | 34 |
| 6. | 15 | 61 |
| 7. | 20 | 28 |
| 8. | 20 | 34 |
| 9. | 20 | 61 |

The ANOVA table contains calculations of degree of freedom (dof), sum of squares (SS), and $F_{value}(F_0)$. The ANOVA table will be shown in Table 2 below.

Table 2: Bidirectional Analysis without Interaction.

| Source of Variation | Degree of freedom (dof) | Sum of square (SS) | Mean of square (MS) | F value $(F_0)$ |
|---|---|---|---|---|
| Factor A | $V_A = kA - 1$ | $SS_A = nA \sum_{i=1}^{n}(A_i - \bar{y})^2$ | $MS_A = \frac{SS_A}{df_A}$ | $\frac{MS_A}{MS_E}$ |
| Factor B | $V_B = kB - 1$ | $SS_B = nB \sum_{i=1}^{n}(B_i - \bar{y})^2$ | $MS_B = \frac{SS_B}{df_B}$ | $\frac{MS_B}{MS_E}$ |
| Error | $V_E = dfT - dfA - dfB$ | $SS_E = dfT - dfA - dfB$ | $MS_E = \frac{SS_E}{df_E}$ | |
| Total | $V_T = N - 1$ | $SS_T = \sum_{i=1}^{n} {y_v}^2 - \frac{T^2}{N \times n}$ | | |

S/N ratio or signal to noise is used to identify factors that contribute less to the response and find out which level of variation influences the experimental results. There are several types of S/N ratio as follows.

**1. Smaller is Better**

Where characteristics with quality close to zero or smaller values are the desired values. The smaller is better value can be determined using the following formula 1.

$$\text{Ratio}\frac{S}{N} = -10\, log_{10}\left(\left(\sum_{i=1}^{n} y_i^2\right)\frac{1}{n}\right) \quad (1)$$

Where:
$y$ = Data from the experiment
$n$ = Number of repetitions

**2. Nominal is Better**

Where the desired value is that the quality is not zero and is limited or close to the desired value. The normal is better value can be determined using the following formula 2.

$$S/N = -10\, log_{10}\left[\sum_{i=1}^{n} \frac{(y_{i-\bar{y}})^2}{n}\right] \quad (2)$$

Where:
$y$ = Data from the experiment
$n$ = Number of repetitions

**3. Large is Better**

Where the desired characteristic is unlimited value quality. The value of larger is better can be determined using the following formula 3.

$$Ratio\ \frac{S}{N} = -10\ log_{10}\left(\frac{1}{n}\left(\sum_{i=1}^{n}\frac{1}{y_i^2}\right)\right) \quad (3)$$

Where:
$y$ = Data from the experiment
$n$ = Number of repetitions

## 3. Resultand Discussion:

### 3.1. Results of Sifter Angle and Rotation on Sieving Time

The results of the length of time for sieving zeolite sand can be seen in Table 3 below.

Table 3: Result of Zeolite Sand Sieving Time.

| No. | Control Factors | | Replication of Sieving Time (s) | | | Average (s) |
|---|---|---|---|---|---|---|
| | Tilt Angle (°) | Tube Speed *(rpm)* | 1 | 2 | 3 | |
| 1. | 10 | 28 | 281 | 257 | 252 | 263,3 |
| 2. | 10 | 34 | 253 | 249 | 230 | 244,0 |
| 3. | 10 | 61 | 241 | 216 | 198 | 218,3 |
| 4. | 15 | 28 | 257 | 241 | 239 | 245,6 |
| 5. | 15 | 34 | 247 | 235 | 213 | 231,6 |
| 6. | 15 | 61 | 242 | 211 | 202 | 218,3 |
| 7. | 20 | 28 | 240 | 235 | 229 | 234,6 |
| 8. | 20 | 34 | 238 | 220 | 215 | 224,3 |
| 9. | 20 | 61 | 221 | 194 | 180 | 198,3 |
| Total Average | | | | | | 230,9 |

### 3.2. Effect of Sifter Angle and Rotation on Sieving Time

The S/N ratio calculation is used to determine the quality of the product under study so as to obtain the best parameters to produce optimal fine sand sieving time based on the Taguchi method experimental design which can be seen in Table 3. The response used in the zeolite sand sieving time results is small is better, indicating that the smaller the value is the desired value, namely the quality is not zero and is limited or close to the desired value. The following is an example of calculating the S/N ratio for sieving time for zeolite sand in the first combination.

$$\text{rasio}\frac{S}{N} = -10\ log_{10}\left(\left(\sum_{i=1}^{n} y_i^2\right)\frac{1}{n}\right) \quad (4)$$

Where :
$y$ = Data form the experiment
$n$ = Number of repetitions

The results of the S/N ratio calculation resulting from the sieving time can be shown as in Table 4 below.

Table 4: S/N Ratio Value Length of Sieving Time.

| No. | Control Factors | | $S/Nratio$ |
|---|---|---|---|
| | Tilt Angle (°) | Tube Speed (*rpm*) | |
| 1. | 10 | 28 | -48,420 |
| 2. | 10 | 34 | -47,755 |
| 3. | 10 | 61 | -46,810 |
| 4. | 15 | 28 | -47,811 |
| 5. | 15 | 34 | -47,313 |
| 6. | 15 | 61 | -46,809 |
| 7. | 20 | 28 | -47,410 |
| 8. | 20 | 34 | -47,026 |
| 9. | 20 | 61 | -45,979 |
| Minimum | | | -48,420 |
| Maximum | | | -45,979 |

To find out the best

combination of parameters, you need to find the average of each level tried. The following is an example of a manual calculation looking for the average response for each level and the average value for each level of the parameters presented in Table 5.

$$X = \frac{-48{,}420 + -47{,}755 + -46{,}810}{3} \quad (5)$$
$$= -47{,}66$$

The calculated data is then presented as in Table 4 below.

Table 5: Average Length of Sieving Time for Each Variable.

| Independent Variable | Average | | | Difference |
|---|---|---|---|---|
| | Level 1 | Level 2 | Level 3 | |
| Tilt Angle (°) | -47,66 | -47,31 | -46,81 | 0,86 |
| Tube Speed (*rpm*) | -47,88 | -47,36 | -46,53 | 1,35 |

Based on the results of the S/N ratio level, it can be concluded that the best combination of parameters to obtain the fastest sand sieving time results is located at level 3 tilt angle and level 3 rotation speed. The following graph of the S/N ratio at each level of process parameters is shown in Figure 3 below.Based on Figure 3, the S/N Ratio graph shows that the tilt angle influences the length of sieving time. The higher the tilt angle used on the sieving machine, the faster the time produced. In this study, tilt angles of 10°, 15° and 20° were used which resulted in the fastest sieving time at the highest tilt angle, namely 20° and 61 rpm with an average sieving time of 198,3 sec and the longest average time was at the angle the lowest is 10° and 28 rpm with an average sieving time of 256,6 sec, because at the angle of inclination there is a gravitational force that pushes the grains of sand downwards, and the flow rate of sand will increase as the angle of inclination increases.

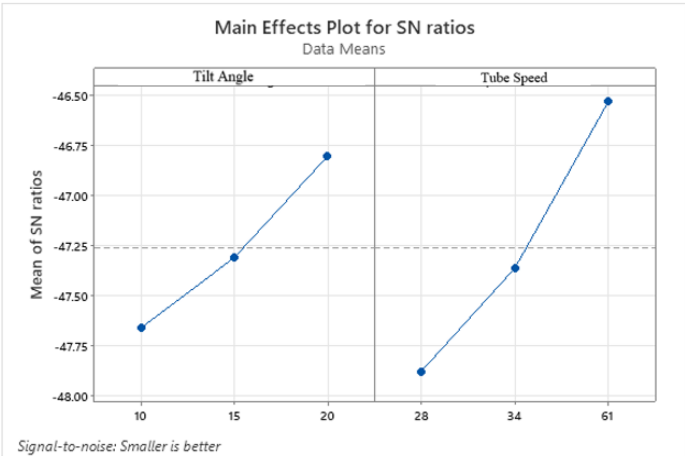

Figure 3: S/N Ratio Graph for Length of Sieving Time

The results of ANOVA calculations and analysis assisted by Minitab software state that the slope angle variable has a calculated $F_{value}$ 5,26 $> F_{(0,05;2;2,26)}$ = 3,028 because $H_0$ is rejected then $H_1$ is accepted, meaning that the slope angle has an influence on results of the sand sieving process time, because the acceleration of an object's motion is influenced by the angle of inclination of the track [7]. The greater the angle of inclination used, the faster the processing time for the resulting sand filter [8].

Based on Figure 3, the S/N Ratio graph shows that rotation speed has an influence on the length of sieving time. The faster the rotation used on the sieving machine, the faster the sieving time produced. In this study, rotation speeds of 28 rpm, 34 rpm and 61 rpm were used which resulted in the fastest sieving time, namely a speed of 61 rpm and an angle of $20^o$, with an average sieving time of 198,3 sec and the longest average time was at a speed of 28 rpm and an angle of $10^o$ with a sifting time of 256,6 sec, because the greater the rotation speed, the greater the centrifugal force which affects the speed of the sand particles and has the potential to speed up the separation process.

The results of ANOVA calculations and analysis assisted by Minitab software state that the rotation speed variable has a calculated $F_{value}$ 13,40 $> F_{(0,05;2;2,26)}$ = 3,028 because $H_0$ is rejected then $H_1$ is accepted, meaning that speed has a high influence on time zeolite sand sieving process, because the higher rotation speed results in faster sifting time due to the higher rate of sand being filtered [9].

### 3.3. Results of Sifter Angle and Speed on Zeolite Sand Size

The results of the angle and speed of the sieve on the size of fine sand can be seen in Table 6 below.

Table 6: Results of Fine Zeolite Sand Sifting.

| No. | Control Factors | | Fine Sand Weight Replication (kg) | | | Average (kg) |
|---|---|---|---|---|---|---|
| | Tilt Angle (°) | Tube Speed *(rpm)* | 1 | 2 | 3 | |
| 1. | 10 | 28 | 6,88 | 6,64 | 6,60 | 6,70 |
| 2. | 10 | 34 | 4,92 | 4,88 | 4,62 | 4,80 |
| 3. | 10 | 61 | 4,88 | 3,56 | 2,48 | 3,64 |
| 4. | 15 | 28 | 4,56 | 4,44 | 4,40 | 4,46 |
| 5. | 15 | 34 | 3,88 | 3,84 | 3,74 | 3,82 |
| 6. | 15 | 61 | 4,08 | 2,88 | 2,08 | 3,01 |
| 7. | 20 | 28 | 3,60 | 3,52 | 3,32 | 3,48 |
| 8. | 20 | 34 | 3,52 | 3,32 | 3,20 | 3,34 |
| 9. | 20 | 61 | 3,72 | 2,52 | 1,78 | 2,67 |
| Total Average | | | | | | 3,99 |

### 3.4. Effect of Sifter Angle and Speed on Zeolite Sand Size

The S/N ratio calculation is used to determine the quality of the product under study so as to obtain the best parameters to produce optimal fine sand based on the Taguchi method experimental design. The response used for fine sand results is Large is better, indicating that the desired value is an unlimited quality value. The following is an example of calculating the S/N ratio resulting from sieving fine zeolite sand in the first combination.

$$\text{rasio}\,\frac{S}{N} = -10\, log_{10}\left(\frac{1}{n}\left(\sum_{i=1}^{n}\frac{1}{y_i^2}\right)\right) \quad (6)$$

Where :
$y$ = Data form the experiment
$n$ = Number of repetitions

The results of calculating the S/N ratio of fine sand can be shown as in Table 7 below.

Table 7: S/N Ratio Value of Fine Zeolite Sand Sieving Results.

| No. | Control Factors | | $S/Nratio$ |
|---|---|---|---|
| | Tilt Angle (°) | Tube Speed (*rpm*) | |
| 1. | 10 | 28 | 16,525 |
| 2. | 10 | 34 | 15,197 |
| 3. | 10 | 61 | 10,863 |
| 4. | 15 | 28 | 12,403 |
| 5. | 15 | 34 | 12,458 |
| 6. | 15 | 61 | 9,143 |
| 7. | 20 | 28 | 10,435 |
| 8. | 20 | 34 | 10,696 |
| 9. | 20 | 61 | 7,895 |
| Minimum | | | 7,895 |
| Maximum | | | 16,525 |

To find out the best combination of parameters, you need to find the average of each level tried. The following is an example of a manual calculation to find the average response for each level and the average value can be found using the following formula 7.

$$X = \frac{16{,}525 + 15{,}197 + 10{,}863}{3} \quad (7)$$

$X$ =14,196

The calculated data is then presented as in Table 8 below.

Table 8: Average Result of Fine Zeolit Sand Sieving for Each Variabel.

| Independent Variable | Average | | | Difference |
|---|---|---|---|---|
| | Level 1 | Level 2 | Level 3 | |
| Tilt Angle (°) | 14,196 | 11,335 | 9,676 | 4,520 |
| Tube Speed (*rpm*) | 13,121 | 12,784 | 9,301 | 3,820 |

Based on the results of the S/N ratio level, it can be concluded that the best combination of parameters to obtain the highest yield of fine zeolite sand sieve is located at level 1 inclination angle and level 1 rotation speed. The following graph of the S/N ratio at each level of process parameters is shown in Figure 4 below.Based on Figure 4, the S/N Ratio graph shows that the tilt angle influences the results of the fine sand sieve. The higher the tilt angle used on the sieving machine the less fine sand will be filtered. In this study, tilt angles of 10°, 15° and 20° were used which produced the most fine sand at the lowest tilt angle, namely 10°, 28 rpm with an average weight of fine sand of 6,70 kg and the average result of the weight of fine sand was slightly, namely at an angle of 20°, 61 rpm with a fine sand yield of 2,67 kg because the greater the angle of inclination used, the less sand filter results.

The results of ANOVA calculations and analysis assisted by Minitab software state that the slope angle variable has a calculated $F_{value}$ 15,90 $> F_{(0,05;2;2,26)}$ = 3,028 because $H_0$ is rejected then $H_1$ is accepted, meaning that the slope angle has a high influence on the results of zeolite fine sand sieves,due to the high gravitational force on the sand sieve tube that will be filtered [10].

Based on Figure 4, the S/N Ratio graph shows that rotation speed has an influence on the results of the fine sand sieve, the faster the rotation used on the sieving machine, the less fine sand will be filtered. In this study, rotation speeds of 28 rpm, 34 rpm and 61 rpm were used, which produced the most fine sand at the lowest rotation speed, namely 28 rpm with an average weight of fine sand of 6,70 kg at an angle of 10°, the sand experienced a decrease in weight at the rotation speed. 34 rpm with an average fine sand weight of 3,82 kg at an angle of 15° and the lowest average fine sand weight result is at a rotation speed of 61 rpm with a fine sand yield of 2,67 kg at the highest angle namely 20°, because the rotation speed of the tube increases, the sand does not have enough time to filter through.


Figure 4: S/N Ratio Graph of Fine Zeolite Sand Sieving Results

The results of ANOVA calculations and analysis assisted by Minitab software state that the rotation speed variable has a calculated $F_{value}$ 13,52 $> F_{(0,05;2;2,26)}$ = 3,028 because $H_0$ is rejected then $H_1$ is accepted, meaning that speed influences the sieve results zeolite fine sand, because the high rotation of the tube creates excessive centrifugal force and can cause the granules to stick to the walls when the machine rotates [11]. As a result of the centrifugal force that occurs, there is pressure in all directions [12].

## 4. Conclusions:

Based on this research, the highest results from the sand sieving process were obtained using a variable angle of 10° and 28 rpm, producing 6,70 kg of zeolite fine sand filter in 256,6 sec. The effect of using a tilt angle and low rpm rotation speed produces high sand filter quality and results in a longer sand filter processing time. The fastest sieving time results were obtained at a variable angle of 20° and 61 rpm resulting in a sieving time of 198,3 sec with a fine sand weight of 2,67 kg. The effect of using a large tilt angle and rpm rotation speed results in lower sand filter quality and results in faster time during the sieving process.

## Acknowledgement

The authors are appreciation to University of Jember for funding this project.

## Conflictof Interest

The authors certify that they do not have any competing interest to declare.

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