UNIABUJA Journal of Engineering and Technology

https://ujet.uniabuja.edu.ng/

ISSN: 2714-3236 (Online); 2714-3228 (Print)

Volume 2, Issue 2, 2025; 1-10

Design and Fabrication of Sieve-Shakers for Particle Size Analysis

Kayode A. IDOWU[1], Nuhu N. AGORO[2*], Alexander C. DANLANG[3], Noye R. NWAKOR[4], Grace S. BASHIRI[5]

[1,2,3,4,5]*Department of Mining Engineering, University of Jos, Jos, Nigeria*

[1*]idkayus@gmail.com, [2]agoronuhu88@gmail.com, [3]daniangalexander3@gmail.com, [4]nwakornoye@gmail.com, [5]gracebashiri2@gmail.com

Abstract

The research focused on the design and fabrication of a set of sieve shakers, an essential equipment in mineral extractive industries for particle size analysis and material separation. The fabrication process involved the selection of appropriate materials, designing a robust frame, and integrating an efficient motor and eccentric mechanism to achieve the desired vibratory motion. The components of the machine are assembled in accordance with ASTM standard by ensuring the quality control measures are implemented. Key considerations were made that include durability, ease of operation, and minimal maintenance requirements. The resulting device was evaluated based on performance metrics such as sieving efficiency, noise levels, and energy consumption, with necessary adjustments made to achieve optimal performance. The efficiency of the machine was 49.75%, which was considered averagely suitable in laboratories and not in industrial settings, to provide a reliable tool for quality control and research applications. The noise level for the sieve shaker was found to be 52 decibels, which falls under acceptable levels according to OSHA. The energy consumption of the sieve shaker was calculated based on the 60 W motor power used as 216 KJ per hour. It is equally observed that the sieve shaker is cost effective because it was tailored to specific need by totally eliminating the costs associated with unnecessary features when compared to commercial alternative. The findings reveal that necessary modifications are required to enhance the performance of the machine, and also optimize the energy use by incorporating a speed regulator or advanced control for future design.

Keywords: *Design, fabrication, sieve shaker, particle size.*

1.0 Introduction

All engineering aspects involve design and fabrication more specifically for mineral processing plants or equipment, which are used for several processes. In separation processes especially particle size analysis, is where sieving techniques are available. During the operation of particle size analysis, many types of screens can be involved, which include grizzly screens, revolving screens, mechanical shaking screens, vibrating screen, electrically vibrated screens, oscillating screen, reciprocating screens and gyratory screens (Li *et al*., 2022; Li *et al*., 2024).

Sieve analysis is a basic essential test for all aggregate technicians. The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirement and verification specification (Aydın and Kurnaz, 2023). The sieve shaker consists of a vibration drive with a set of sieves installed, including tray, cover and device for fastening the sieves. The intermediate rings and trays are selected depending on the size of the mesh or the apertures in the perforated plate (Adindu *et al*., 2023).

The process of sieving particles is described by determining the free passage of particles in the sieves, that is, whether the particles will pass through the selected holes as undersize or retain on the sieve as oversize, or will blind the passage. This method allows the effect of variation on both particle sizes on the sieve and particle sizes to be evaluated. The efficiency of sieve in giving a sharp cut between undersize and oversize is very much influenced by small variation in aperture sizes (Li *et al*., 2022). The main use of sieving is for size analysis. A nest of sieves of decreasing aperture sizes is commonly used to obtain data on size distribution of samples. A sample is placed on the coarsest sieve. This nest of sieve is vibrated so that particles on the sieve are presented to apertures in the surface of the sieve (Li *et al*., 2024).

Smaller particles, which are smaller than the aperture will pass through and fall into to lower sieve while the larger particles, which are larger than the aperture will be retained. In this way a vertical classification, based on the size of particles relative to sieve apertures is obtained. Although sieves are fabricated to a particular opening or mesh size, in practice either due to fabrication process or due to subsequent wear evasion of the sieves (Afeni *et al*., 2021). The hole will not all have the same size, a distribution of sizes will exist. The sieving process is indeed complex, involving the interaction of particles of various sizes and shapes with a range of hole sizes. Specific rules must be applied to determine whether particles pass through the

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025

https://doi.org/10.70118/ujet.2025.0202.01

sieve (undersize), or are retained on the sieve (oversize), or become lodged in the sieve apertures, thereby reducing the effective area (Adindu *et al*., 2023).

The initial work to interpret sieving was based on deterministic model using dimension analysis. Rate constant was defined for blinding of opening of a sieve "anti-blinding" (the freeing of an aperture) and particle passage through the sieve. By solving the number balance equation, expression for oversize retained on the sieve and undersize passing through the sieve can be obtained. It is still difficult however, to estimate the effect of blinding, to allow for the effect of machine or screen wears and to account for non-uniformity of the hole sizes. It is with these problems in mind that a stochastic model using a Monte Carlo simulation technique has been developed (Adindu *et al*., 2023; Aladejare *et al*., 2024).

The key issues in designing and fabrication of sieves for particle analysis include:

1. ***Screening***

Screening is the separation of mixture of various sizes of grains into two or more portions by means of screening surfaces. Screening is a process used in separating particles based on their sizes. It involves passing a mixture of particles through a screen or sieve with specific openings.

The materials remaining on the screening surface are categorized as oversize or undersize, while those retained on the subsequent surface are referred to as intermediate materials.

2. ***Types of screens***

Grizzly screen: This consists of a set of parallel bars held apart by spacer at some predetermined opening. The bars are made of manganese steel to reduce wears. A grizzly screen is widely used before ore or rock enters the vibrating screen. The grizzly screen is commonly employed for preliminary screening ahead of coarse and medium crushing operations for materials. Typically, it features a mesh size greater than 50mm, though occasionally less than 25mm.

Revolving screen: Revolving screen once widely used is held apart by vibration screens. They consist of cylindrical frame surrounded by wire cloth or perforated plate open at both ends and inclined at a slight angle. The materials to be screened are delivered at the upper end, and the oversize is discharged at the lower end. The product falls through the wire cloth openings. The screen revolves at a relatively low speed of 15 to 20 r/min.

Mechanical shaking screen: This screen consists of a rectangular frame, which holds wire or perforated plates and is slightly inclined and suspended by loose rods or cables or supported from a base frame by flexible flat springs. The frame is driven with a reciprocating motion. The material to be screen is fed at the upper end and advance by the forward stroke of the screen while the finer particles pass through the openings. In many screening operations, such devices have given way to vibrating screens (Kim *et al*., 2021).

Vibration screens: Vibration screens are mechanical devices that employ vibrating wire meshes or perforated plates to categorize or separate products into various fractions based on particle size, while also eliminating contaminants such as torn bag pieces. They are highly effective for sorting and sifting bulk granular or powder-type products of diverse shapes and dimensions. These screens classify fractions as oversize, good, and fine, determined by the dimensional particle sizes of the product, making them ideal for internal quality control and assurance. There are two main types of vibratory screens: circular, which are always horizontal, and linear, which can be horizontal or inclined. Both types can feature 1, 2, or 3 decks using wire mesh or perforated plates to achieve the desired separation of product fractions.

Oscillating screens: Oscillating screens are known, used in the separation of solid materials. Known oscillating screens are provided with a screening container of rectangular shape and with a weight of several tonnes, inside which a screening means is disposed, lying on a relative screening plane, inclined by a pre-set angle with respect to a horizontal oscillation plane. The screening container rests on a fixed supporting structure having supporting legs positioned at the corners of the screening container. Each supporting leg has shock-absorber elements made of elastomer material. The screening container is moved in oscillating manner with respect to the fixed supporting structure by means of a rotary shaft, at an angular velocity comprised between about 100 revs and 300 revs per minute, bearing at a terminal part an eccentric element, with which the lower part of the screening container cooperates. This cooperation between the eccentric element and the screening container occurs by means of suitable mechanical coupling elements.

Reciprocating screens: These screens have many applications in the mineral processing work. An eccentric under the screen supplies oscillation, ranging from gyratory about 2m diameter at the feed end to reciprocating motion at the discharge end. Frequency is 8 to 10 oscillation per second (550 to 600 r/min), and since the screen is inclined to about 5°, a secondary high-amplitude normal vibration of about 0.0025m (1/10m) is also set up.

Gyratory screens; They are box-like Machines, either round or square, with a series of screen cloths nest a top on another. Oscillation supplied by eccentric or counter weights, is in a circle or near circular orbit. In some machine, a supplementary whipping action is set up. Most gyratory screens have auxiliary vibration

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025
https://doi.org/10.70118/ujet.2025.0202.01

caused by ball bouncing against the lower surface of the screen cloth. Machines of these types are operated continuously and can be located in line in pneumatic conveying systems as scalping screens.

3. Screen surface

The selection of the proper screening surface is very important, and the opening wire diameter and open area should all be carefully considered. The four general types of screening surface are woven-wire cloth, silk bolting cloth, punched plated, and bar of rod screens (Pryor, 1965).

Woven-wire cloth: This type has by far the greatest selection as to screen opening, wire diameter, and percentage of open area. Thousands of specifications are available from over 0.10m (4m) clear opening top 500 meshes. Woven-wire screens are obtainable in a verity of metals and alloys. Steel and high carbon steel are generally favored for the coarser openings, because of their abrasion –resistance qualities, and other materials such as phosphor bronze, move and stainless steel are used for their corrosion resisting or non-contamination qualities (Dierig, 2006).

Silk bolting cloth: This material originated from Switzerland and is generally woven from twisted multistrand natural silk. The system for number and grades for both bolting cloth and grafts gauge has been handed down from the original Swiss weavers. In recent years, nylons and similar synthetic materials woven largely from monofilament have been introduced. The nylon grades are generally designated by their micrometer opening and are available in light standard and heavy weights.

Punch plate: These are available in a variety of separations including round square hexagonal and elongated openings. Punched metals will generally wear larger than wire cloth and has more rigidity, which is an advantage in certain applications. However, it usually does not give the capacity per unit areas that wire cloths does and is generally heavier. Its use is normally limited to the coheres separation.

Bar screens: These are generally used in handling large and heavy pieces of material. They are formed from rails, rods, or bars, suitable shape, made from rolled steel or castings, fixed in parallel position and held by cross bars spacers. Bars, which taper in thickness from top bottom and may also taper in width from one end to the other, are recommended because they tend to avoid blinding (Turgut *et al*., 2023).

4. Working principle of vibrating screens

The purpose of screening is to separate from a granular substance particle that are smaller than the screen opening from those that are larger. This is not as simple as it sounds, and the difficulties compound as the opening becomes smaller. For example, if a sample of a crushed mineral ore containing 50% by weight of particles smaller than 1/8″ is dropped on a static test sieve, most of the undersize will remain on the screen, with only a trickle passing through. Now if the sieve is subjected to some kind of motion, reciprocating or gyratory in the horizontal plane, or shaken with a reciprocating motion having both vertical and horizontal components, the minus 1/8″ particles will begin to pass through the screen, at a diminishing rate until all but the particles closest to the opening size have been separated out.

5. Factors in selecting screen equipment

In attempting to pick a screen machine for a specific problem, the use of generalized formulae and charts to predict screen capacity of the screen machine will give only an approximate value. This is because of many variables, which may affect performance. Screen consultants will readily admit that they must depend largely on laboratory tests and field experience.

Width is necessary to reduce the bed thickness to a practical maximum length to allow the undersize to be removed without an inordinate number of fines in oversize. In attempting to choose a screening machine for a particular screen application the consumer and manufacturer should consider the following:

i. Full description of the material involved, including the name and the type of the material, bulk density and physical characteristics such as hardness, particle shapes flow characteristics (free flowing, sluggish, or sticky, percent of moisture and temperature).
ii. Normal and Maximum total rate of feed screen.
iii. Complete screen analyses of screen feed, including maximum lump size, and sieve analysis of desired product.
iv. Other important factors include method of delivering feed to the screen, open or closed circuit; open or enclosed screen previous screening experience with the material flow sheet or description of related equipment operating hours per day, power available and space limitation.

6. Method of feed

The screening must be fed properly in order to obtain maximum capacity and efficiency. The feed should be spread evenly over the full with of the screen cloth and approach the screen surface in a direction parallel to the longitudinal axis of the screen and at as low practical velocity as is possible (Liu, 2009).

Mesh and space cloth – wire cloth is generally specifics by "mesh", which is the number of per linear mesh counting from center of any wire to a point exactly 25.4 mm (1m) distant or by opening specified in inches or millimeter, which is understood to be clear opening or space between the wire. Mesh is generally favored for cloth 2 mesh and finer and clear opening for space cloth of 12.7 mm (1/2 inch) opening coarser.

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025

https://doi.org/10.70118/ujet.2025.0202.01

Aperture: Aperture or screen size opening is the minimum clear space between the edges of the opening in the screen surface and is usually given in inch or millimeters.

2.0 Materials and Methods

2.1 Materials

The sieve shaker was constructed using mild steel bars, bevel gears, and bearings. Welding was used to join the frame components such as the mild steel mesh of various mesh sizes, while bolts and nuts were used for detachable parts. These materials were selected based on their superior mechanical and physical characteristics, including strength, ductility, mach-inability, weld-ability and availability, corrosion resistance, lightweight properties, and cost-effectiveness. The followings are the materials used for the fabrication work.

i. Metal (mild steel) for the frame
ii. Mesh screen (metal or synthetic)
iii. Bolts and nuts
iv. Springs (for shaker mechanism)
v. Motor (for automatic shaker)
vi. Rubber or plastic gaskets
vii. Bearings
viii. Paint or protective coating.

Tools: The tools used are listed below:

i. Welding machine (for metal frame)
ii. Saw (for cutting metal)
iii. Drill
iv. Screwdriver
v. Measuring tape
vi. Hammer
vii. Pliers
viii. Wrench
ix. Sandpaper

Table 1 shows the number of materials used in the construction of sieve shaker with their corresponding quantities.

Table 1: Number of Materials Used and their Quantity

Part number	Part name	Material	Quantity
1	Sieve guide	Stainless steel	1
2	Cover	Steel	1
3	Mesh	Steel wire	5
4	Sieves	Mild steel	5
5	Receiver pan	Steel	1
6	Sieves carrier	Aluminum	1
7	Bearing	Steel	3
8	Bevel gears	Stainless steel	2
9	Bolts and nuts	Mild steel	6
10	Spring	Spring steel	4
11	Vibrating tray	Aluminum	1
12	Vibrating motor	Copper	1

The specific material choices depend on many factors such as load-bearing capacity, corrosion resistance, durability and cost effectiveness. These components are designed to withstand the rigors of vibration and material handling, while also ensuring safety and efficiency.

2.2 Methods

2.2.1 Fabrication

The fabrication of a sieve shaker involves a structured approach to design and manufacturing. This begins with defining the requirements and specifications of the sieve shaker, including the type ofof appropriate

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025

https://doi.org/10.70118/ujet.2025.0202.01

materials and components of the sieve shaker, and also the type of minerals to be sieved, the desired particle size range, and the operational parameters such as vibration frequency and amplitude. A detailed design was then developed, considering factors like mechanical advantage, vibration generation, and ergonomics. Computer-aided design (CAD) software was used to create a digital model to simulate the operation, and optimize the design. The sequence of operation for the fabrication of set of sieve shakers are layout, cutting, drilling, wedding, filling, sand papering and painting.

To establish the layout of various components that make up the equipment, engineering materials such as the protractor, steel ruler, center punch, hammer and scriber were used to mark out the basic parts needed for the fabrication of the tray. Before cutting, the sieve and shaker were designed to meet specific requirements such as size, mesh specifications (for sieves), and mechanical features (for shakers). This stage involved determining the dimensions, material selection, and overall functionality.

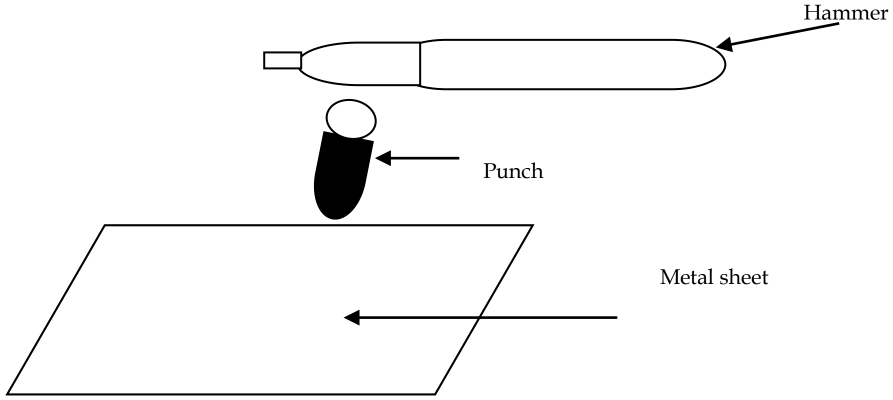

Figure 1: Layout of the fabrication materials

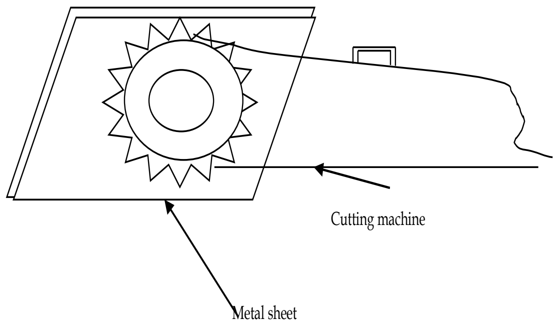

Figure 2: Cutting process

Figures 1 and 2 show the layout cutting process for the fabrication of a sieve and shaker. Based on the design specifications, appropriate materials such as mild steel, stainless steel, spring steel, aluminum and copper were selected for durability and corrosion resistance. For the sieve, the cutting involved shaping the mild steel sheet into a circular frame, and then cutting or/and weaving the mesh to the required aperture size. This was done using a laser cutter or punching machine, depending on the material thickness and precision. In the case of the shaker, the cutting involved fabricating the components such as the base frame, screen trays, and any other structural elements. This involved the cutting of metal sheets to form the frame and trays.

The center punch and hammer were used to locate the exact point to be perforated. After center punching of the top plates, it was drilled with the electric-drilling machine so that it can be joined with the help of tightening screw to the shaker casing. Also, drilling was primarily used to create holes or perforations in the materials that have been cut to size during the initial fabrication stages. These holes serve various purposes depending on whether you are fabricating a sieve or a shaker: In the case of a sieve, drilling is crucial for creating mounting holes in the frame to secure the mesh. These holes allow the mesh to be attached firmly to the frame, ensuring it remains taut and effective in filtering or separating particles of specific sizes. And for a shaker, drilling is used to create holes in the base frame or trays. These holes are necessary for attaching components such as vibration motors, fasteners for securing the screens or trays. Figure 3 shows the drilling process.

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025
https://doi.org/10.70118/ujet.2025.0202.01

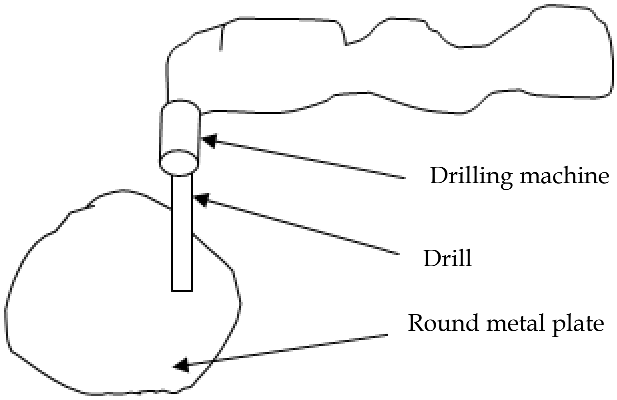

Figure 3: Drilling process

Throughout the drilling process, quality control measures were implemented to check dimensions, hole alignments, and overall product integrity. This ensures that each sieve or shaker component meets the specified design requirements before proceeding to assembly. After drilling, welding is often the next crucial step in the fabrication of sieves and shakers. Welding is used to join metal components together permanently. In the context of sieves and shakers, the welding was employed to attach the mesh to the frame securely. This ensures that the mesh remains tightly stretched and fixed within the frame, allowing for effective particle separation without the risk of the mesh becoming loose or detached. Also, for shaker, welding was used to assemble various structural components of the shaker, such as joining the base frame to the sides, attaching support brackets and securing screen trays within the frame. Figure 4 shows the welding process.

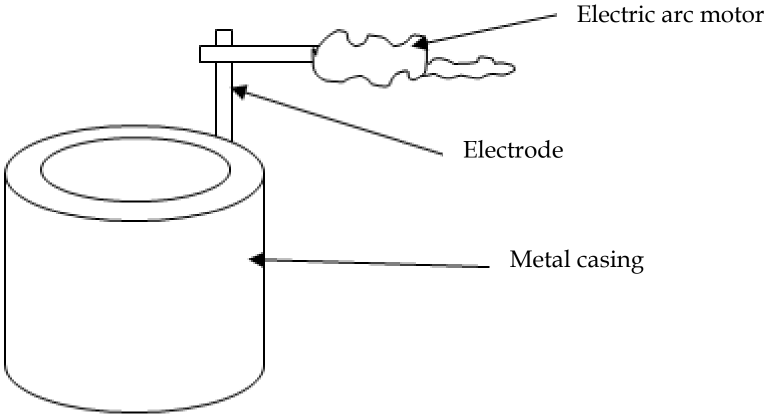

Figure 4: Welding Process

The welded zone was filled with body filler mixed with cream hardener in order to cover the tiny holes on the welded edges as a result of the intermediate welding method used. The second filling operation was then carried out with the same hand-filling machine. This was done on the welded zone that was filled so as to produce smooth surface and edges while the sand papering was done using a rough emery cloth, and later smooth emery cloth was used to improve the smooth appearance of the work After the sand papering operation, the sieves were sprayed with aluminum paint and the other parts of the machine were sprayed with blue paint by the use of direct drive sprayer to help preserve it against corrosion, and to give it a good appearance as well. Figure 5 shows the painting process.

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025
https://doi.org/10.70118/ujet.2025.0202.01

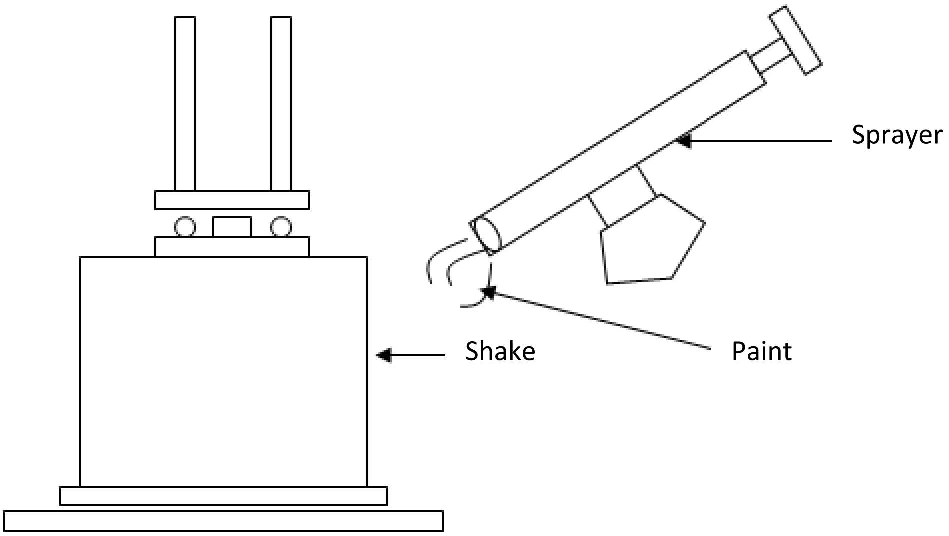

Figure 5: Painting Process

2.2.2 *Assemblage*

The component parts were assembled together so as to set up the required set of sieve and shaker. The off centered flat plate was fixed to the amateur of the motor. The motor casing was fixed and screwed in position to give the designed equipment. The set of sieves were then arranged from the coarsest to the finest sieve and then to the pan (as shown in Figure 6).

Figure 6: Fabricated Selective Sieves

2.2.3 *Calculation of Sieve Efficiency*

On the basis of the total weight of sample taken and the weight of sand retained on each sieve, the percentage of the total weight of soil passing through each sieve was as calculated below;

$$P = \frac{W_r}{W_t} X100\% \quad (1)$$

where,
P = percentage of soil retained on a particular sieve
W_r = retained weight (g), on each sieve
W_t = total weight of sand taken (g)
The cumulative percent of sand retained was obtained as;
CP = Sum of percentage sand retained for sieve 1-5 and pan.
The sieve efficiency is obtained as;
E = sum of the weights of the material passing through each sieve/ sum of the total weights of the material introduced to each sieve × 100.

3.0 Results and Discussion

The results from the experimental design and fabrication were analyzed.

3.1 Experimentation and performance analysis

The performance analysis of the newly designed set of sieve shaker machine was carried out by comparing grain size distribution and size determination of particles (cumulative grading curve) obtained with the machine for a sand sample with that obtained using the fabricated machine. Figures 7 and 8 show the set of sieves shaker fabricated.

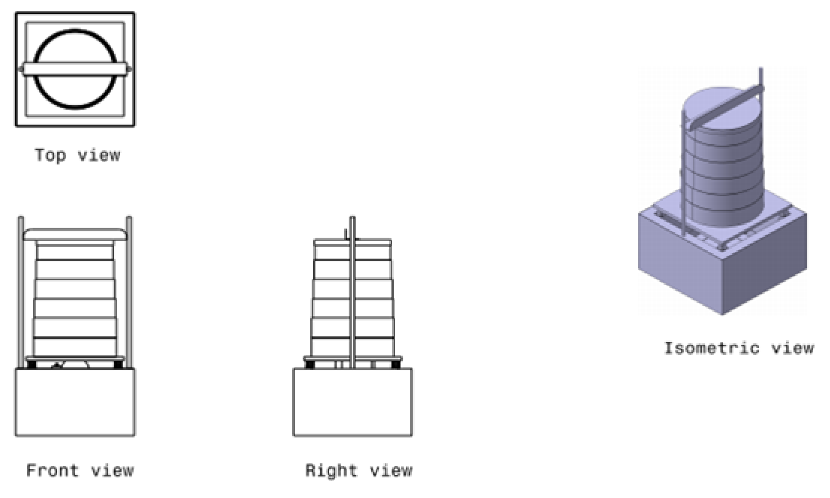

Figure 7: Fabricated set of Sieves Shaker

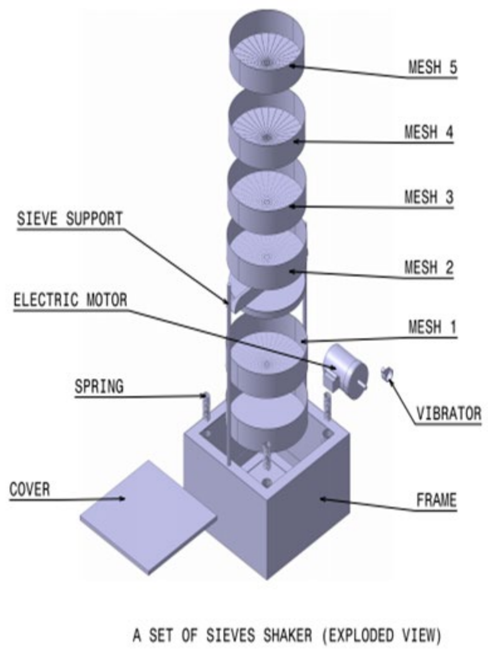

Figure 8: Fabricated set of sieves shaker (exploded view)

From the clay-free sand grains obtained at the University of Jos, Naraguta Campus, 200g of the dried sand was placed in the top sieve of the fabricated sieving machine and covered, with the other sieves stacked in the order of decreasing mesh size from the top to the pan. The sieve shaker was then switched on for the materials to be sieved for about 2 minutes. The various sieves were then taken apart and its content weighed, including the pan. The content in each sieve was also weighed, including the pan. The results of sand grain size distribution and its sieving efficiencies obtained with the fabricated sieving machine shaker are presented in Table 2.

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025
https://doi.org/10.70118/ujet.2025.0202.01

Table 2: Results of sand grain size distribution and sieving efficiency

Sieve number	Weight retained (g)	Percentage retained (%)	Cumulative percentage retained (%)
1	15	7.5	7.5
2	32	16.0	23.5
3	20	10.0	33.5
4	29	14.5	48.0
5	25	12.5	60.5
6 (pan)	78	39.0	99.5

3.2 Discussion

The efficiency of the machine is then calculated as the cumulative percentage of sand retained/total weight of sand fed into sieve × 100.

$$E = \frac{99.5}{200} X\ 100 \quad = 49.75\% \qquad 2$$

where:
E = Efficiency of the machine, which is 49.75%.

During the design and fabrication of the sieve shaker, various factors were observed that influenced the Efficiency of the machine. These include; sieve mesh size, shaking time, amplitude and frequency, and load size. It is important to note that the standard sieving efficiency according to American Society for Testing and Materials (ASTM) ranges from 85% to 95%, depending on the specific test method and material being analyzed. The precautionary measures taken include the use of Personal Protective Equipment (PPE) such as goggles, hand gloves, safety boot, during the workshop operations and accurate measurement of dimensions and readings of weights were ensured they followed the International Society of Rock Mechanics (ISRM) standard. The findings also prioritized the noise level for the sieve shaker which was 52 dBA, lower than 55 dBA. According to Occupational Safety and Health Administration (OSHA), this is considered acceptable noise level. The machine was fabricated with a motor of 3.5 Horse power to meet the capacity of its usage in the Mineral Processing Laboratory of the Department of Mining Engineering, University of Jos. In determining the exact average energy consumption of the sieve shaker, which was quite challenging, the motor power rating used was 60 W, and thereby result to 216 KJ per hour (60 W x 3600s).

4.0 Conclusion

The fabrication process involves the selecting suitable materials and manufacturing techniques, such as machining and welding to create the components. The components are then assembled, and sieve shaker is integrated with necessary features like vibration motors, control systems, and safety mechanisms. Quality control measures are implemented to ensure the sieve shaker meets the required standards and performance criteria. The final product was tested for functionality, efficiency, and durability, with any necessary adjustments made to achieve optimal performance. A custom-designed sieve shaker can be tailored to specific needs, potentially reducing costs associated with unnecessary features. However, the researchers were curious about the efficiency of the sieve shaker and thereby suggest and recommend that there is need to include a speed regulator as part of the future design modifications to enhance performance, reduce energy consumption and give better efficiency for mining operations. In addition, the energy consumption can vary significantly depending on the specific applications, materials and type of design. Therefore, to reduce energy consumption, we recommend adjustable speed settings or advanced controls that optimize energy use.

References

Afeni, T. B., Adebanjo, T. L., Idowu, K. A. & Akindutire, T. (2021). "Design and Fabrication of Fueless Dewatering Machine for Small and Medium Scale Miners". *Journal of Inventive Engineering and Technology (JIET)*, 1(1), 1-11. http://jiengtech.com/index.php/INDEX/article/view/10

Aladejare, A. E, Idowu, K. A. & Ozoji, T. M. (2024). "Reliability of Monte Carlo Simulation Approach for Estimating Uniaxial Compressive Strength of Intact Rock". *Earth Science Informatics, Springer Nature*, https://doi.org/10.1007/s12145-024-01262-1

American Society for Testing and Materials (2014). "Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under varying states of Stress and Temperatures". *ASTM International, West Conshohocken, PA*, D7012-14.

Aydın, M., & Kurnaz, T. F. (2023). "An Alternative Method for the Particle Size Distribution: Image Processing". *Turkish Journal of Engineering*, 7(2), 108-115. https://doi.org/10.31127/tuje.1053462

Dierig, J. (2006). “Choosing a Woven Wire Screen for Top Separation Performance. Technical Report, Powder and Bulk Engineering, *15*.

ISRM (1999). “Committee on standardization of laboratory and field tests”. Suggested methods: Rock characterization, testing, and monitoring. E.T. Brown, ed., Pergamon Press, London, Great Britain, 21.

Iyasara, A. C., Nduka, J. A., & Irogbele, G. C. (2023). “Design and Fabrication of Mechanical Sieve Shaker for Particle Size Analysis of Ceramics”. *J. Eng. Res. Rep*, *24*(8), 12-19.

Kim, H., Ilyas, S., & Srivastava, R. R. (2021). “Pre-treatment, Concentration, and Enrichment of Precious Metals from Urban Mine Resources: Pre-treatment, Concentration, and Enrichment of Precious Metals”. In *Sustainable Urban Mining of Precious Metals,* CRC Press, 35-65.

Li, D., Tang, Y., Yang, Y., Huang, Y., Z., Tong, R., Yang, S. & Manocha, D. (2022). N-Cloth: Predicting 3D Cloth Deformation with Mesh-Based Networks. In *Computer Graphics Forum* (Vol. 41, No. 2, pp. 547-558).

Li, S., Liu, C., Liu, H., & He, D. (2024). Prediction and optimization of screening performance of three-deck vibrating screen based on surrogate model. *International Journal of Coal Preparation and Utilization*, *44*(6), 626-645.

Liu, K. (2009). “Some Factors Affecting Sieving Performance and Efficiency”. Powder Technology, *193*(2), 208-213.

Pryor, E. J., & Pryor, E. J. (1965). “Industrial Sizing and Sorting”. *Mineral Processing*, 179-232.

Turgut, S., Yenisoy, Y., Mohamadi, Y. & Torun, K. (2023). “Sizing and Structural Analysis of Mechanical Bar Screen”. *The Eurasia Proceedings of Science Technology Engineering and Mathematics*, *22*, 268-273.

Received: 13-01-2025 / Accepted: 05-03-2025 / Published: 19-05-2025
https://doi.org/10.70118/ujet.2025.0202.01