Automatic Sand Filter and Separation System

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***Abstract*—This automatic sand filtration and separation system is an economical and efficient device used to separate granules and other unwanted particles from a particular size of sand. This has a wide range of applications across various industries. This system is based on advanced sieving technologies which make the system cost-effective and user-friendly along with high efficiency. The system helps to separate stones, granules, nails, lumps, and other unwanted particles to achieve perfect uniformity of sand, which is required for quality construction. This method is based on the principle of vibration, in which the use of vibration helps to separate unwanted matter from the sand automatically. The system can be used across various industries such as construction, agriculture, and domestic purposes. A variety of sieve sizes can be obtained/sieved in the same system by changing the sieve. The system is small and easily portable due to its lightweight and durable material along with installed wheels at the bottom of the frame. The mechanism and interface of the system are so easy that there is no need for skilled labour/operators. The 3HP motor vibrates the sieving frame with the help of a 12V.-9AH watt battery so that there is no need for an electric connection at the site. The use of stainless steel makes the system more durable in comparison to other systems available in the market.**

I. INTRODUCTION

For high-strength/high-performance concrete, sand is the most important component/material. The durability of construction work depends on the quality of the sand. High/good quality sand improves the properties like strength and durability of construction work. In traditional construction practices, the sand is extracted from natural resources like rivers, where it may contain impurities and unwanted particles which degrade the quality of construction work. Due to increasing urbanization, there is a high demand for clean and good quality sand. Manual filtration of sand is a more costly and time-consuming method. This increases the labour workload; hence, the labour cost at the construction site also increases. To overcome this problem, an automatic sand filtration machine can be used. The operation and maintenance of the sand filtration machine system are user-friendly and cost-effective. Thus, the labour workload is reduced and the overall project cost is reduced.

Sand filtered from an automatic sieving machine removes unwanted particles such as small rocks, coal lumps, nails, and other unwanted particles to achieve good quality sand for quality construction work. In comparison to other machines present in the market, this machine is lightweight and has better mobility, which makes this machine portable from one side to the other side. Also, various sizes of sand can be sieved through this machine.

1.1 Slider Crank Mechanism

A slider-crank mechanism is a mechanical arrangement used to convert rotary motion into reciprocating motion or reciprocating motion into rotary motion. It consists mainly of a crank, connecting rod, and slider working together to transfer motion from one component to another.

In internal combustion engines, this mechanism converts the up- and-down movement of the piston into rotational motion of the crankshaft. Similarly, in pumping systems, rotary motion is transformed into linear reciprocating motion through the same mechanism. In this project, the slider-crank mechanism is used to generate reciprocating motion for the sieve box. The rotary movement produced by the motor is transferred through the crank and connecting rod, causing the sieve box to move back and forth continuously. This reciprocating action helps in effective screening and separation of sand particles according to their size.

The working principle of the slider-crank mechanism is based on kinematics, which deals with the study of motion of bodies without considering the forces acting on them. The mechanism operates through the combined motion of the crank, connecting rod, and slider to produce rotary or reciprocating movement.

The motion of each component in the mechanism can be explained in terms of position, velocity, and acceleration. When the crank rotates, the connecting rod transfers the motion to the slider, causing it to move in a straight line. The relationship between the rotating crank and the linear movement of the slider is determined using geometrical and trigonometric principles. Kinematic equations are used to analyze the movement of the mechanism under different operating conditions. These equations help in understanding the displacement, speed, and acceleration of the slider during operation, which is important for designing smooth and efficient mechanical systems.

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1.2 Applications of Slider-Crank Mechanism

The slider-crank mechanism is an important mechanical arrangement used to convert rotary motion into reciprocating motion or reciprocating motion into rotary motion. Due to its simple construction and efficient working, it is widely used in many mechanical and industrial applications. Some important applications are given below:

- Internal Combustion Engines: In engines, the slider-crank mechanism converts the reciprocating motion of the piston into rotary motion of the crankshaft, which helps in producing power for the vehicle or machine.
- Pumps and Compressors: The mechanism is used in reciprocating pumps and compressors to transfer liquids or gases from one place to another by converting rotary motion into linear motion.
- Mechanical Presses: In presses used for operations such as punching, stamping, and forging, the slider-crank mechanism is used to apply force on the workpiece through reciprocating movement.
- Robotics and Automation: The mechanism is used in robotic systems to produce controlled linear motion required for operations such as welding, assembly, and material handling.
- Toy Vehicles: In certain toy cars and models, the slider-crank arrangement converts the rotational movement of wheels into linear movement of different parts.
- Human-Powered Machines: The mechanism is also used in bicycles, rowing machines, and similar equipment where linear motion produced by pedals or handles is converted into rotary motion for movement or operation.

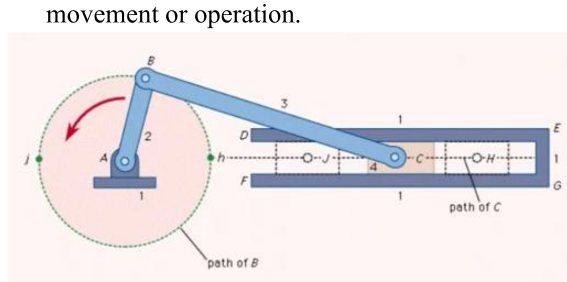

Fig. Side crank Mechanism

II. LITERATURE SURVEY

A. Design and Fabrication of Domestic sand Sieving Machine Alan Biju, Alwin Thomas, Akash J Kalarickal, Jeswin Jose, Rittin Abraham Kurien, Conventional practices like winnowing require highly expertise hand movements considering gravity, aerodynamics and centrifugal force. This is the major difficulty observed in the winnowing process. Nowadays people always prefer the most suitable way to save time and energy. This project proposes a domestic sieving machine which can easily remove unwanted particles from the grains, nuts and other pulses automatically.

B. Automatically Driven Sand Sieving Machine P.R. Gajbhiye, Rupesh Khode Pratik Sukhadeve, Vicky Chaple Construction of buildings requires sand as an important ingredient Sand is used at different stages in construction right from the foundation to the finishing work i.e. plaster. This sand needs to be screened properly for various stages in construction, i.e. size of sand for construction work is slightly coarse whereas that used for plaster work is fine These processes are carried out manually. Sand is carried out using rectangular mesh which is inclined at certain angle. This causes a relative motion between the particles and the sieve. Depending on their size, the individual particles either pass through the sieve mesh or retained on the sieve surface

C. Development of NCAM Reciprocating Cassava Mash Shifter Abiodun L.O., Oladipo N.O and Bamidele B.L. The NCAM cassava mash sifter was developed to tackle the problems of high labor, expense associated with manual sifting, time wastage, the tedious mature of the operation, injury to the hand or palm as one rubs against the raffia sieve continuously, back ache, caused by prolonged sitting in one position during manual sifting, low productivity, and the hygienically unsafe nature of manual sifting as products are exposed to germs.

D. Stacked Siever for Natural Sand Processing W.D. Handoko, N. Widiastuti, G.S. Budi, K. Karelius, S. Pratapa This stacked sand sieve was intended to replace conventional sieves that had several disadvantages, including unstable speed, inefficient time in processing large amounts of sand, and relatively higher costs incurred.
This stacked sieve exhibited the following characters: 1) composed of two sieves, 2) can be assembled easily to change the size of the sieve, 3) had 3 variations of the sieve slope, and 4) used a gasoline motor to produce a sift speed of 25.2 cm/s and 36.4 cm/s. The sieve slopes were manually adjusted by positioning the sieves according to the available slots on the device.

E. Energy-based Indicators of Soil Structure by Automatic Dry Sieving Dmitry Fomin, Maria Timofeeva, Olga Ovchinnikova, Ilya Valdes-Korovkin, Andrey Holub, Anna Yudina Numerous methodological approaches and fractionation procedures contribute to the continuation of discussions about soil aggregate formation. This study aims to justify the dry sieving procedure and suggest an optimal sieving regime for automatic shakers for soil samples. For this approach to calculating total sieving energy, using oscillation frequency, vibration amplitude, and time was proposed. Retisol, Phaeozem, and Chernozem topsoil samples from agricultural and native ecosystems were analyzed using a sieving test, in which 50-kg soil samples were divided into 500–700 g subsamples and sieved with a constant oscillation frequency (50 Hz), but with varying vibrational amplitudes (0–2.5 mm), for sieving times that ranged from 1 to 5 min. We found that the optimal sieving regime is characterized by total sieving energy of 1850 J kg− 1, reached during 2 min of sieving with a 50 Hz frequency and a 2.5 mm amplitude. Based on results of the dry sieving test, we have proposed the indicators of mechanical stability of soil structure: index of soil structure stability (SS) which characterize the degree of change in the soil aggregates size during sieving with minimal and optimal sieving energy, and modified the soil friability index (F4), that characterizes the rate of change in the soil aggregates size under mechanical load by dry sieving. The proposed formula of total sieving energy calculation allows comparing results between soil studies. Our meta-analysis showed that most (26 of 34) studies used insufficient sieving energy, where the aggregate size distribution did not reach the equilibrium state. A detailed protocol for soil dry sieving analysis is provided.

F. Quality attributes of parboiled rice prepared with a parboiling process using a rotating sieve system Naruebodee Srisang, Thatchapol Chungcharoen The aim of this study is to apply a rotating sieve system to the parboiling process for parboiled rice production. The parboiling time and rotation speed were the main production factors affecting the quality attributes of the parboiled rice, including the degree of starch gelatinization (DG), fissure percentage, head rice yield (HRY), white belly, and color. The results showed that the parboiling process with a rotating sieve can decrease the parboiling time required to provide an even quality of parboiled rice. The parboiling time for an even quality of parboiled rice was 5 min at rotation speeds of 10 and 15 rpm, while the parboiling time at a rotation speed of 5 rpm was 10 min. These times were shorter than that with a fixed sieve (15 min). Moreover, the parboiling process using a rotating sieve system provided better quality of parboiled rice than that using the fixed sieve system, including higher DG and HRY and lower fissure and whiteness percentages. Additionally, the values of DG and HRY were increased with increasing parboiling time. In contrast, the fissure and whiteness percentages of parboiled rice decreased. However, the quality of the parboiled rice was not dependent on the rotation speed.

G. Shredding and sieving thermoplastic composite scrap: Method development and analyses of the fibre length distributions Guillaume A. Vincent, Thomas A. de Bruijn, Sebastiaan Wijskamp, Mohammed Iqbal Abdul Rasheed, Martin van Drongelen, Remko Akkerman Recycling of thermoplastic composites has attracted considerable attention in the recent years. Several recycling solutions include shredding scrap to centimetre-sized flakes to retain long fibres, followed by a remanufacturing step that prevents fibre breakage. Determining the exact fibre length distribution (FLD) for these routes is crucial, as it is of importance for the processibility of the material as well as the mechanical performance of the recycled parts. In this paper, novel analysis methods are introduced to calculate FLDs based on photographs of flakes. The reliability of the method and of the sampling was found to be high. The relation between flake size and FLD was studied, showing that offcut layup barely influences the FLD in comparison to flake size. The effects of shredding settings and sieving were studied, showing a strong correlation between machine parameters and FLD, whereas the offcut size was found to have no effect on FLD. H. Intelligent optimal sieving method for FACTS device control in multi-machine systems Qiang Lu, Wencong Wang, Chen Shen, Shengwei Mei, Masuo Goto, Akihiko Yokoyama A multi-target oriented optimal control strategy for FACTS devices installed in multi-machine power systems is presented in this paper, which is named the intelligent optimal sieving control (IOSC) method. This new method divides the FACTS device output region into several parts and selects one typical value from each part, which is called output candidate. Then, an intelligent optimal sieve is constructed, which predicts the impacts of each output candidate on a power system and sieves out an optimal output from all the candidates. Artificial neural network technologies and fuzzy methods are applied to build the intelligent sieve. Finally, the real control signal of FACTS devices is calculated according to the selected optimal output through inverse system method. Simulation has been done on a three-machine power system, and the results show that the proposed IOSC controller can effectively attenuate system oscillations and enhance the power system transient stability.

III. COMPONENT

Components used in sand filter:

1. Caster wheels
2. Supported Frame
3. Shaft
4. Bearings
5. Battery

1. Caster wheels: A caster (also castor according to some dictionaries) is a wheeled device typically mounted to a larger object that enables relatively easy rolling movement of the object. Casters are essentially special housings that include a wheel, facilitating the installation of wheels on objects. Casters are found virtually everywhere, from office desk chairs to shipyards, from hospital beds to automotive factories. They range in size from the very small furniture casters to massive industrial casters, and individual load capacities span 100 pounds (45 kg) or less to 100,000 pounds (45 t). Wheel materials include cast iron, plastic, rubber, polyurethane, forged steel, stainless steel, aluminum, and more.

Fig. Caster Wheel

2. Supported Frame

Fig. Supported Frame

The supported frame is used to support the components. The total arrangement depends on this frame. This frame is made of iron or mild steel.

3. Shaft

A shaft is a rotating machined element used to transmit power from the source of the machine to other parts of the machine. The shaft is generally circular in cross section. it is one of the essential parts of any machine. Because without shafts, the machine will not be going to transmit power. The pulley & gears are generally placed on the shafts, which will help to transmit motion. Not only pulley and gear but also many other rotating elements can mount on the shaft with the help of a key. For power transmission, one end of the rotating shaft is connected to the power source & the other to the machine. It may be solid or hollow, depending upon the type of application. The hollow shaft reduces its weight and gives an added advantage. The geometry of the shaft is different as per the application. Sometimes it is straight & sometimes it is stepped. The straight shafts are supported & guided with bearings to transmit power. Stepped shafts are for mounting different gears or hubs to transmit power. With every step, its diameter changes with the length. The bearings at the ends of the shafts for the guiding & supported on the rigid structure to absorb vibration developed. An E-clip or Circlip in the groove of the shaft prevents it from coming out from the bearing. Depending upon the geometry & application of the shafts, it will be subject to bending & torsional stress.

4. Bearings:

A bearing is a mechanical component used in machines to support and guide moving parts while restricting unwanted motion. Its main function is to allow controlled movement, such as rotation or linear motion, while reducing friction between the contacting surfaces. The design of a bearing depends on the type of motion required. In some cases, it allows smooth rotation around a fixed axis, while in others it supports straight-line movement of a part. It can also be designed to limit or control certain directions of movement by managing the forces acting on the component. Bearings help in reducing wear and tear between moving parts by minimizing friction, which improves efficiency and increases the service life of the machine. Based on their working, motion type, and load direction, bearings are classified into different categories.

5. Metallic net:

A metal net is a type of structure formed by joining or weaving thin metal wires or strands together to create a flexible barrier. It can also be made using other materials that are strong yet bendable, such as certain fibers or ductile metals.

Fig. Metallic Seive

A mesh has a similar structure to a net and is made by interlinking or weaving strands in a regular pattern. It forms a network-like surface with uniform openings between the wires or threads, giving it strength while still allowing air, liquid, or small particles to pass through depending on its use.

2.2 Working Process

The figure shows the sand filter and separator. In this the whole work is based on the crank and slider mechanism. The rotation of the crank transfers the motion to the movement of rectangular shape filter. It consists of the pulley and belt arrangement which rotates the crank and through it slider consists of oscillating mechanism. The power is transmitted to the crank and slider mechanism. This mechanism is used to rotate the crank, the pulley which has an extended rod is connected to the sliding portion of the rectangular plate directly by means of a linkage. The rectangular plate is passed through the guide ways by means of maintaining the cutting axis. The rectangular sieve moves linearly on guided path. The crank is connected to the flywheel which transfers the motion from one to another. The flywheel is connected to another wheel which is connected to the rectangular filter plate through belt. The rotating motion of the electrical motor converts to the sliding motion using two flywheels and belt. The sliding crank mechanism is used in this project. The flywheel which is placed at the top is used as crank and connecting rod in between the rectangular plate and flywheel.

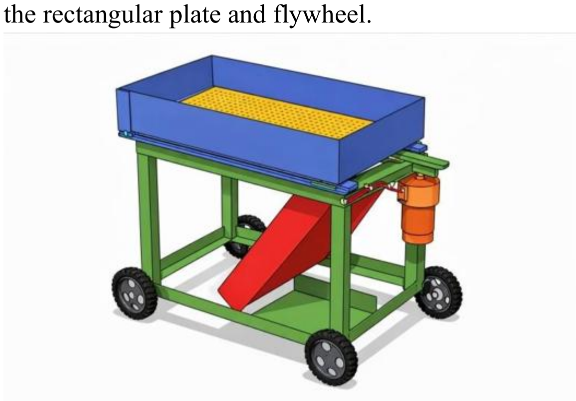

Fig. Working Prototype

A. Advantages

This machine is easy to use and portable.

Operates on both battery and power source so that can be used in remote places.

Increases productivity

Worker's intervention is removed. Only one man can handle this machine.

Construction of sand filtering machine

Now let us see the construction of machine in step-by-step Mechanical construction

The device should be suitable for local manufacturing capabilities.

Mechanical construction

Initially take 25X3 angle and cut it the below sizes.

1) 30 cm – 4 nos.
2) 45 cm - 2 Nos.
3) 32 cm - 2 Nos.
4) 29 cm - 2 Nos.
5) 24 cm - 2 Nos.

Construct rectangle of 35 X 45 cm angles

Attach legs of 30 cm length to above rectangle it will become table of size 35 width 45 length 30 height.

Prepare one more rectangle of size 29 length X 24 width.

Attach mesh of 29X24 mm dimensions to the above rectangular frame.

Mount motor mounting L clip on base table

Also mount bearing with appropriate shafts on the rectangular base frame.

Place rectangular mesh on the bearing base Mount motor on "L bracket"

Attach crank on the motor shaft with proper 3.0 mm nut bolt.

Connect mesh and motor crank with 25X3 flat pieces.

IV. CALCULATION

Machine Efficiency Let's assume averagely we use machine for 5 hours a day, Then power consumption for 30 days (1 month) = $30\times5\times0.375 = 56.25$ unit

So Total cost of electricity for one month = 56.25×10 =562.5Rs.

9.2 Manpower Efficiency Labor cost of a worker =Rs.50/hour

For 1 month working 5 hour per day It will take around = Rs.$50\times30\times5$ =Rs.7500 9.3 RPM

Diameter of pulley on motor =5″

Diameter of larger pulley on intermediate shaft = 14″

Diameter of smaller pulley on intermediate shaft = 5″

Diameter of larger pulley on main shaft = 10″

Speed of the motor shaft = 1400rpm Speed of the intermediate shaft = 300rpm So, rpm of the machine = 90rpm

V. COMPARISON

Manual Sieving	Automatic Filter & Separetor
For 1 Brass Sand Required Time – 2 to 3 Hours.	For 1 Brass Sand Required Time – 30 min To 1 Hour.
Suitable For Small – Scale Work.	Suitable For Small As Well As Large-scale Construction Work.
Require More Manpower.	Require Less Manpower.
Inconsistent Quality Of Sieved Sand.	Consistent Quality Of Sieved Sand.
Time Consuming.	High Efficiency & Speed.
Zero Energy Dependency.	Energy Required.
Low Maintenance Risk.	High Maintenance Risk.
Weather Dependency.	Automation & Continuous Operation.

VI. CONCLUSION

The design and fabrication of the motorized sand filtering machine were successfully completed, and the overall performance of the machine was found to be effective and reliable. The developed system simplified the process of sand sieving and reduced the difficulties associated with manual filtering methods. By using the slider crank mechanism, the machine was able to provide smooth and continuous motion, resulting in efficient separation of sand particles through the sieve.

The project demonstrated that the machine can significantly reduce human effort, save time, and improve productivity in construction related work. Compared to the traditional manual method, the machine requires less manpower while delivering better efficiency and consistent output. The fabricated model is simple in design, easy to operate, and cost-effective, making it suitable for practical applications.

During the study, the strength and performance of the mild steel structure under different loading conditions were also analyzed successfully. The results indicated that the structure can withstand the operational requirements of the machine. Although the initial setup cost is relatively higher than manual sieving methods, the increased productivity and reduced labor dependency make the machine economically beneficial for commercial use in the long run.

Furthermore, the project highlighted the possibility of improving the machine for larger domestic and industrial applications by incorporating a higher capacity motor, an efficient gearbox system, and a stronger structural frame to enhance durability and overall performance.

VII. FUTURE SCOPE

The motorized sand filtering machine has considerable scope for future development, especially in the construction industry where efficient material handling is essential. Owing to its simple mechanism and effective working principle, the machine can be further developed to handle larger volumes of sand at large-scale construction sites.

In addition to sand filtration, the machine can also be adapted for other material separation processes, such as applications in gold and silver jewellery industries and similar industrial operations. For these advanced applications, the use of a more powerful motor and an improved gearbox arrangement would help achieve greater efficiency and higher operational capacity.

The overall capacity and performance of the machine can also be enhanced by modifying the design parameters and increasing the dimensions of the structure according to industrial requirements. Different mesh sizes may be used depending on the desired particle size and the nature of the material being filtered, thereby increasing the flexibility of the machine for various applications.

Another promising area for future development is the integration of solar energy as a power source for operating the machine. The use of renewable energy can reduce electricity consumption, lower operational costs, and make the system more environmentally sustainable and economically efficient for long term use.

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