DESIGN AND ANALYSIS OF SOLAR POWERED TROMMEL SCREEN

PROJECT REFERENCE NO: 38S0965

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Introduction:

A trommel screen is also known as rotary screen is mainly used in the mineral and solid waste processing industries. It consists of a perforated cylindrical drum which is normally elevated at an angle at the feed end. Physical size separation is achieved as the feed material spirals down the rotating drum, where the undersized materials smaller than the screen aperture passes through the screen, while oversize material exists at the other end of the drum.

Field crop residues are considered one of the most critical problems which face the farmers. Accumulation of these residues in large quantities results not only in deterioration of the environment but also in a loss of potentially valuable material.

Manuring with these residues through composting is a promising route, especially with the increase in fertilizer price. Composting is the biological reduction of organic wastes to humus. The good composting structure depends on the correct mixing and turning of materials as well as, after maturity the correct screening of the produced compost. Screening improves the quality of the produced compost for sale or use by removing unwanted objects such as rocks, metals, clumps, and other trash.

There are many factors that control the performance of compost cleaning machine. These factors can be divided into two sections: machine and material. Machine variables include sieve speed, sieve inclination angle, screen opening size and feeding rate. Moreover, material variables such as compost moisture content and degree of compost maturity are considered critical factors. The mentioned factors affect directly on the compost losses, efficiency, productivity, energy and cost requirements.

Trommel Screen is a screen cylinder used to separate materials by size. The trommel screen plays the replacement of vibration screens and disk screens as it is vibration free, easy maintenance, cheaper to produce and higher durability. From the design and built point of view the trommel screen does not require a whole lot of resources, technological advancements and monetary input when compared to the other screens such as vibrating screens and disk screens, whereas it works on basic principles of physics and requires little amount of research and development. Hence building a trommel screen results in implementing the technical knowledge into practical aspects and this has been the main motivation of carrying out the project.
Objectives:
The objectives of this project work is to:

- To replace the conventional methods by the non conventional energy sources.
- To design and optimize the trommel screen performance by trail and error methods.
- Utilize a trommel screen for cleaning compost to increase product quality.
- Optimize some different operating parameters affecting the performance of the trommel screen. i.e.,
  - Material feed rate
  - Sieve speed
  - Screen opening size
  - Sieve inclination angle
  - Compost moisture content
- Evaluate the trommel screen performance from the economic point of view.

Experimental work:
Brief Working Of The Model:
The solar panel absorb the incoming solar radiation and charges the battery. This is connected to a motor that rotates the belt drives via pulleys. The rotational motion of the belt drives is transmitted to the periphery of the wheel rims and in turn rotates the trommel (cylindrical mesh structure). Material feeds into the drum, is lifted by the rotation and aerated as it falls down. This action is repeated with each revolution along the length of the drum. The finer material passes through the screen openings while the lager material tumbles towards its eventual exit at the rear of the drum. Hence, a coarse feed (say from a primary crusher) is fed at the upper end of the grizzly. Large chunks roll & slide to the lower end (tail discharge) while small lumps having size less than the opening in the bars fall through the grid into a separate collector.
Materials and Specifications:

- DC Motor – 12V 250rpm
- Battery – 12V 7A
- Solar Panel – 12V 10W
- Cycle Rim – 21” dia
- Mesh – 8x10mm
- Wire Tie – MS 3mm
- Pulley – MS 50mm dia, 40mm width
- Belt – V-belt B12
- Support Frame – MS pipe frame, 38mm thick
- Turnnions – 2” nylon wheel

Torque

Torque required to rotate the trommel is calculated first,
For given, Weight of Drum = 10kg
Radius of Drum = 0.27m
Therefore, Torque = 9.81 x W x R
i.e.,
\[ T = 9.81 \times 10 \times 0.27 \]
\[ = 26.487 \text{ N-m} \]

- Power
Now, Power required to produce above torque is calculated,
By using, \( P = T \times \omega \)
\[ = (26.487 \times 2 \pi \times 25)/60 \]
\[ = 69.34 \text{ W} \]

- Ampere
Therefore, Ampere required is found out by,
\[ P = VI \]
\[ I = 5.77 \text{ A} \]

Solar Power Requirements Calculations:
• **Watt Hours Figure of a Battery**

For a 7AH, 12V battery the Watt Hours figure is,

\[ 7 \times 12 = 84 \text{ WH} \]

This means the battery could supply 84W for 1 hour, or 42W for 2 hours i.e., the more energy you take, the faster the battery discharges.

• **The power consumption of Motor is 69.34 W**

• **Power generation rating of solar panel is given by,**

  Amt of energy the solar panel = \( W \times H \times 0.85 \) can supply to the battery

  where, 0.85 - natural system losses

  Therefore, for the solar 10W panel in 1 hrs sunshine gives,

\[ 10 \times 1 \times 0.85 = 8.5 \text{ WH} \]

Therefore, to run the motor(69.34W) for 1 hour, the solar panel of 10W should be kept in sunshine for approx of 8 hrs.

Note: As no. of panel increased by ‘n’, the time to be kept in sunshine decreases..

• **Adjustment of Sieve Speed:**

  Critical sieve speed is given by,

\[ N = \frac{60}{2\pi} \sqrt{\frac{g}{r}} \]

  where, \( r = 0.27 \text{m} \)

  Therefore, \( N = 42.56 \text{ rpm} \)

• **Material Velocity:**

\[ V_{est} = N x = ND \tan \alpha \]

\[ = 25 \times 0.54 \times \tan 5 = 1.18 \text{ m/min} \]

• **Drum Diameter:**

  Dia of drum = 0.54m

  Effective flow area,

\[ A_f = (\pi D^2/4) \text{ sq-m} \]

\[ = 0.229 \text{ sq-m} \]

• **Drum Length:**

  Length of the drum ranges from 2 to 6 times of diameter.

  Therefore, \( L = 2D \)

\[ = 1.08 \text{m} \]

• **Residence Time:**

  Residence time of material in drum is calculated using,
T = L/V
= 0.9 min

RESULTS AND DISCUSSIONS:

Fig. Effect of some operating parameters on machine productivity and separating efficiency under different screen opening sizes.
CONCLUSION:
The project is motivated from the advantages of trommel screen over vibrating screens and reduction of time, labour cost and increased efficiency for segregation of compost. The project goal is to efficiently produce trommel screens that can run using solar power. From the experiments that were carried out the segregation of particles were smooth and reliable. With the optimum time and optimum feed the segregated can be replaced by the old conventional methods. And by the use of solar or green energy and by trial and error basis the best suitable optimum condition has been adopted for the design and performance analysis of the solar powered trommel screen.

Experiments were carried out to evaluate the performance of a trommel screen for compost cleaning to increase product quality. Theoretical analysis was conducted for optimizing sieve speed and sieve inclination angle. The machine performance was studied as a function of change in material feed rate, screen opening size and compost moisture content. Performance evaluation of the trommel screen was carried out in terms of machine productivity, separating efficiency, compost losses, cleaning efficiency, required power, energy requirements and criterion cost.

The experimental results reveal that compost losses as well as criterion costs were minimum while, separating and cleaning efficiencies were maximum under the following conditions:

- Operate the trommel screen at a sieve speed of 25 rpm (1.18 m/min).
- The slope angle of the cylindrical sieve on the horizontal plane (Sieve inclination angle) should be lower than 15 degrees.
- The screen opening size should be of about 10 mm.
- Clean compost at a moisture content of about 25-30%.
- Operate the trommel screen at an average feed rate of 4 kg/min.
SCOPE FOR FUTURE WORK:

Trommel screen is a simple screening device used to segregate particles by size. The trommel screen plays the replacement of vibration screens and disk screens as it is vibration free, easy maintenance, cheaper to produce and higher durability. Lot of research is carried out in this field to improve the ergonomics and efficiency of the trommel screen and there is a scope for advancements in this regard.

Some of the improvements that can be made are

- Increase the screening efficiency by altering the material feed rate, drum speed, inclination angle, and other parameters.
- By making portable trommel screens, i.e., easy removal and insertion of trommel screens, so that mesh sizes can be changed for different requirements.
- By replacing steel mesh with plastic mesh to reduce the load of the drum so that the power required to rotate the drum can be reduced.
- Making hopper arrangements to feed the materials and also to guide the materials in a proper way.
- Introducing altering speed settings to alter the trommel speed according to the necessity.