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Development And Testing Of A Cereal Sieving Machine

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ABSTRACT

Sieving operation has been an age long practice of separation which is carried out manually or mechanically. The manual method is laborious and time consuming. This, therefore, work presents the development and testing of a cereal sieving machine. The test was carried out with corn seedlings already detached from the cob. The seedlings were ground and weighed. The different ground and weighed samples were then put in the machine for sieving. The time taken for the sieving operation was then taken. The test results showed that the machine efficiency was about 80 %, with an average output rate of about 0.026 kg/sec and a percentage loss of about 20 %. With these results, the machine could be said to be suitable for performing the function of sieving satisfactorily and, would be best suited for use in homes for subsistence operation or for use in small businesses such as Micro, Small and Medium Scale Enterprises (MSMEs).

Key Words: Sieving, cereal, mesh, efficiency.

NOTATION

r_1 Radius of Motor Pulley

r_2 Radius of Shaft Pulley

N_1 Speed of Motor Pulley

N_2	Speed of Motor Pulley
ω_1	Angular velocity of Motor Pulley
ω_2	Angular velocity of shaft Pulley
F_c	Force on Connecting Rod
d_s	Diameter of Shaft
L_c	Connecting Rod Length
m_b	Mass of Belt

1. INTRODUCTION

Sieving is a method of using a sieve to distinguish small particles from bigger particles. It is a separation technique used to remove impurities such as husks and stones are extracted from cereal family, such as: wheat, sorghum, millet, barley, guinea corn, maize, rice etc [1, 2]. This is a processing method which evolved many years ago [3]. During sieving the sample is subjected to vertical movement (vibratory sieving) or horizontal motion (horizontal sieving) [4].

Sieving technology employs different techniques to separate components of different mixtures through a screening. During this process the particles are compared with the apertures of every single sieve. The probability of a particle passing through the sieve mesh is determined by the ratio of the particle size to the sieve openings, the orientation of the particle and the number of encounters between the particle and the mesh openings. The appropriate sieving method depends on the degree of fineness of the sample material [4, 5]. Test sieves with round apertures are used for a variety of agricultural products including corn (4.50/4.75 mm), sorghum (1.8 mm), oilseeds (starting from 0.5 mm), soybeans, different cereals and numerous others [6]. Dry sieving is the preferred method for the size range between 40 µm and 125 mm. Wet sieving extends the measurement range to 20 µm. If wet sieving is not permitted, air jet sieving is an alternative which provides acceptable results down to 10 µm [7].

The screening surface may consist of woven wire, silk or plastic cloth or a perforated punched plate. Separation can also be achieved difference in phase densities of mixture (hydrostatic separation) or employing fluid fluid and particle mechanics of materials. The components may vary in size, phase and chemical composition, such as: liquid-liquid; liquid-gas; liquid-solid; gas-liquid; solid-solid etc [8, 9, 10]. Seiving machine varies from the traditional (manual) sieves, semi-automatic and automated sieves.

This work dwells on the development of a reciprocating sieving machine for solid-solid separation using wire mesh as the screening surface. With this sieving method, the sample is thrown upwards by the vibrations of the sieve bottom and falls back down due to gravitation forces [7].

2. DESIGN ANALYSIS

The some components' design was based of the relevant constitutive relations:

2.1 Belt

The relation between the belt tension is [11]:

$$\frac{T_1}{T_2} = e^{\mu\alpha cosec\frac{\theta}{2}} \quad (1)$$

2.2 Shaft

Diameter of shaft is [12]:

$$d = \left(\frac{16}{\pi S_s}\sqrt{(K_b M_b) + (K_t M_t)^2}\right)^{\frac{1}{3}} \quad (2)$$

2.3 Connecting rod

Critical load on the connecting rod is [13]:

$$P_{cr} = \frac{\pi^2 EI}{(\mu l)^2} \quad (3)$$

3. SPECIFICATION

The following parameters were obtained using appropriate conditions and Equations derived from Equation (1) to Equation (3).

Radius of Motor Pulley (r_1)	30 mm
Radius of Shaft Pulley (r_2)	90 mm
Speed of Motor Pulley (N_1)	1440 rpm
Speed of Motor Pulley (N_2)	480 rpm
Angular velocity of Motor Pulley (ω_1)	150 rads/s
Angular velocity of shaft Pulley (ω_2)	50 rads/s
Force on Connecting Rod F_c)	1330 N
Diameter of Shaft (d_s)	30 mm
Connecting Rod Length (L_c)	200 mm
Mass of Belt ($m_{b)}$	0.165 kg/m

4. MATERIALS AND METHOD

The machine consists of the frame, vibrating screen with 4 .5 mm aperture, shaft, electric motor, hopper, discharge chute etc. The parts, having been designed and sized were assembled as shown in Figure (1).

The test was carried out with corn seedlings already detached from the cob. The seedlings were ground and weighed. The ground and weighed corn was then shaken together vigorously to ensure a uniform mix. The different weighed samples were then put in the hopper of the sieving machine. The machine was then put on for sieving operation. During this operation, the ground corn particles drop on the sieve mesh which was regulated by the slide valve. The time taken for the sieving operation for each test was then recorded. In all, eight tests were carried out with different weighed samples ranging from 1.5 kg to 5 kg. The sieved particles (fine particles) of corn grains discharged though the cute and collected inside a container, while the coarse particles remained on the sieve mesh and were collected separately in a different container. Thereafter, the weight of the sieved corn grains (fine particles) and the coarse particles were weighed to determine the effectiveness of the machine.

5. RESULTS AND DICUSSON

Table (1) shows the result of the test from the sieving operation.

Table 1: Test results

Test	Ground Corn (Fine + Coarse Grains)	Mass of Fine Grains		Coarse Grains		Time Taken (sec)
	Input (kg)	Output (kg)	Output (%)	Output (kg)	Output (%)	
1	1.50	1.30	86.67	0.20	13.33	40
2	2.00	1.63	81.50	0.37	18.50	52
3	2.50	1.79	71.60	0.71	28.40	59
4	3.00	2.06	68.67	0.94	31.33	98
5	3.50	3.02	86.29	0.48	13.71	117
6	4.00	3.44	86.00	0.56	14.00	132
7	4.50	3.68	81.78	0.82	18.22	141
8	5.00	3.92	78.40	1.08	21.60	154

From Table (1), it could be observed that the cumulative input of ground corn was 26 kg; the cumulative output of fine grains was 20.84 kg, while the cumulative output of coarse grains was, 5.16 kg. From the test results, it was observed that the percentage output rate of fine grains decreased progressively from a value of about 0.033 kg/sec at the first to a value of about 0.021 kg/sec in the fourth test. An increase in output rate of about 0.026 kg/sec was observed at the at the fifth test and this value persists up to the final test, Figure (2). This could be attributable to the intermittent clogging and cleaning of the aperture of the sieve. The machine efficiency (cumulative percentage output of fine grains) was about 80%, while the cumulative output (discharge) rate of fine grains was about 0.026 kg/sec and percentage loss (cumulative percentage of coarse grains) was about 20%. These values were gotten by the relations below:

The machine efficiency (cumulative percentage output of fine grains) was,

$$= \frac{cummulative\ mass\ of\ fine\ grains}{cummulative\ mass\ of\ ground\ corn} = \frac{20.84}{26} = 80.15\%$$

The cumulative output rate of fine grains,

$$= \frac{cummulative\ mass\ of\ fine\ grains}{cummulative\ time\ taken} = \frac{20.84}{793} = 0.026 kg/sec$$

Percentage loss (cumulative percentage of coarse grains),

$$= \frac{cummulative\ mass\ of\ coarse\ grains}{cummulative\ mass\ of\ ground\ corn} = \frac{5.16}{26} = 19.85\%$$

6. CONCLUSION

The development and testing of a cereal sieving machine has been presented. The test results showed that the machine could be said to be suitable for performing the function of sieving satisfactorily. With an efficiency of about 80 %, an average output rate of about 0.026 kg/sec and a percentage loss of about 20 %, the machine would be best suited for use in homes for subsistence operation or for use in small businesses such as Micro, Small and Medium Scale Enterprises (MSMEs).

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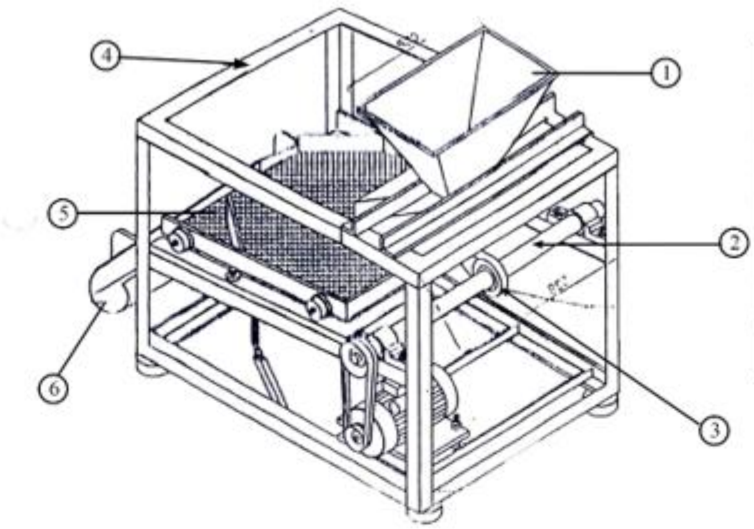

LEGEND	
S/N	DESCRIPTION
1	HOPPER
2	SHAFT
3	CRANK
4	FRAME
5	VIBRATING SCREEN
6	DISCHARGE CHUTE

FIG.1: ISOMETRIC VIEW OF VIBRATING SCREEN

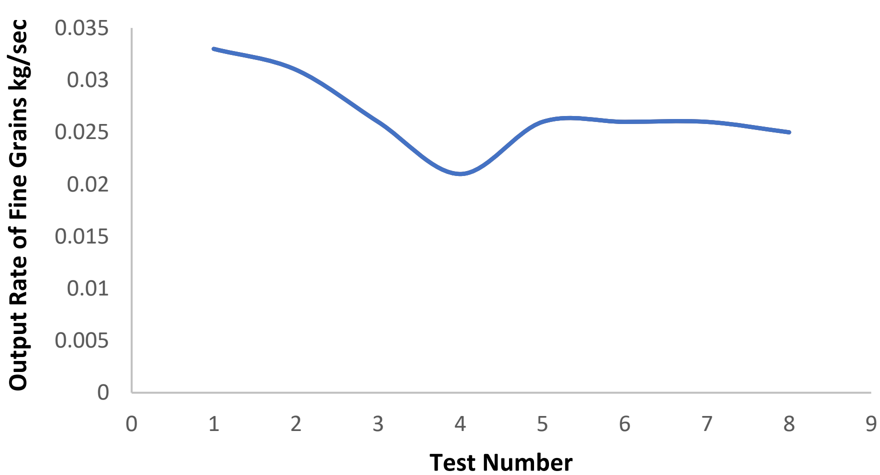

Fig. 2: Relationship between test number vs output rate of fine grains