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Performance Evaluation of a Triple Layer Electric Sieving Machine (TLESM)

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ABSTRACT

A multi-layer sieving machine is of multiplayer and highly efficient sieving machine that retains particles based on the difference in size. This study was carried out to evaluate the performance of a multi-layer electric sieving machine. The performance test of the machine was carried out in the Agricultural department farm of the Federal College of Forestry, Jericho Ibadan. The electrical sieving machine was used to carry out separation operations on a mixture of food crop materials at varying speeds. The machine passed the test of workability; it was able to perform the specific function of sieving and separating food materials of varying sizes. Mixed food materials were poured in the first layer of the mesh assembly and sieved. The time to completely separate the mixture into the three different layers was recorded and the respective weight of each layer was finally measured. Layer 1 had a mean weight gain of 0.42kg; layer 2 had a mean weight gain of 0.14 while layer 3 had a mean weight loss of 0.56kg when sieving was done for 5 minutes; at 7 minutes, Layer 1 had a mean weight gain of 0.1kg; layer 2 had a mean weight gain of 0.18 while layer 3 had a mean weight loss of 0.28kg, while at 10 minutes, the first layer had a mean weight gain of 0.06 kg, second layer also had mean weight gain of 0.02 while the third layer had a mean weight loss 0.08. The mean efficiency was highest at 99% in all the layers when sieving operation was carried out for 10 minutes and lowest at 96% for layer 3 when the machine ran for five (5) minutes. The effect of change in speed suggests that increment in sieving speed above 750rpm or below 300rpm gives a low efficiency.

Keywords**--** Sieving, Performance, Throughput, Efficiency

I. INTRODUCTION

Food production against the world population growth has always made the farmers to use the minimum facilities and available machines to mechanize farming and increase their cultivated land to achieve the ultimate goal which is increasing production and improving product quality (Noormohamadi and Zareiean, 2003). Separation techniques are used to separate mixtures into its constituent elements and/or compounds. Depending on the physical and chemical properties of the substances in the mixture, we can choose the most appropriate separation technique to isolate them from the mixture. (Atkins, T. 2009).

Sieving

Sieving is an uncomplicated practice for sorting out the particles of different sizes (Ganeshram, 2013). The sieve is responsible for retaining the larger particles. The word "sift" derives from "sieve".

Sieving Machine

The sieving machine is handy to construct and can be operated easily. Sieving machine according to McCave and Syvitcki, (1991) is of multiplayer and highly efficient. Sieving machine is a separation technique based on the difference in particle size. The sieve is responsible for retaining the larger particles On top of size; other factors play a role in determining whether a particle will pass through the sieve or not. Vibrating screens and sieves are vital in the beneficiation of mineral particles needed by other beneficiation plants in order to produce the final mineral concentrates demanded by the customers (Pocwiardowski and Korpal, 2010; Pocwiardowski and Wodzinski, 2011a, 2011b; Pocwiardowski *et al.*, 2012).

The working principle of the Sieving Machine mainly depends on converting rotary motion provided by D-C motor which runs either by 3-9volt battery or using 24V DC adapter which is used to convert AC to DC and applies current to the motor. Wet sieving is a process very prominent in processing both cereal grains like maize, guinea corn, millet and root tubers like cassava into local diets and beverages such as Ogi (pap), Kunun and Burukutu (Inyang and Dabot, 2007). There are a lot of wet sieves around e.g Gari and cassava mash sieves (Nweke *et al*, 1986). Also, a wide variety of designs for screens exist differing in the complexity of their construction and their efficiency of operation. Basically rotating, vibrating screens and pusher-type centrifuges are used (Asiedu,

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1990). Sieves are effective provided they are made to vibrate (Fellows and Hampton, 1992). The throughput of sieves is dependent upon a number of factors; chiefly the nature and amplitude of the shaking; the methods used to prevent sticking of the sieve, the tension and physical nature of the sieve material (Earle, 1983). If the vibrating screen is a of a double deck family the undersized particles will undergo the same process (but with reduced aperture size) before passing to a subsequent stage of processing (Mamlouk and Zaniewski, 1999).

The utilization of technology enhances ease and speed of separating mixed particles. This study focuses on using technology to separate mixed agricultural products of varying sizes. It therefore considers separating a mixture of rice, beans and flour using a triple layer electrical sieving machine.

Table 1: Physical parameters of selected food produce

FOOD CROP	COLOR	SHAPE
Rice	White	Cylindrical
Beans	Dark Red	Kidney Shaped
Flour	White	Powdery

II. MATERIALS AND METHODOLOGY

The machine was designed to enhance the separation of agricultural produce both for commercial and non-commercial purposes. It was to help avoid the use of human labor, reduce the use of crude methods in sieving or separating agricultural or food produce when they are unintentionally mixed.

Description of the Machine

The Triple Layer Electrical Sieving Machine (TLESM) is made up of the following components;

Electric motor … this converts electrical energy into rotational force or torque and transmits it through its pulley.

Mesh assembly … a high surface finish mild metal sheets were used as mesh to allow the passage of materials. The meshes were arranged in layers such that the topmost layer has meshes with the larger holes, the second layer with a smaller holes and the last layer was sealed to trap materials as the final destination.

Pulley and belt … a pulley and belt mechanism was used to transfer torque from the motor to the frame carrying the bearings that mobilizes the mesh assembly. The belt was ensured to be the suitable size for the pulleys.

The Main frame … the main frame supports the entire weight of the machine. The total weights carried by the main frame are: Weight of the electric motor, Weight of the mesh layers, Weight of the bearings and pulleys.

Figure 1 below is the pictorial view of the three layer electrical sieving machine;

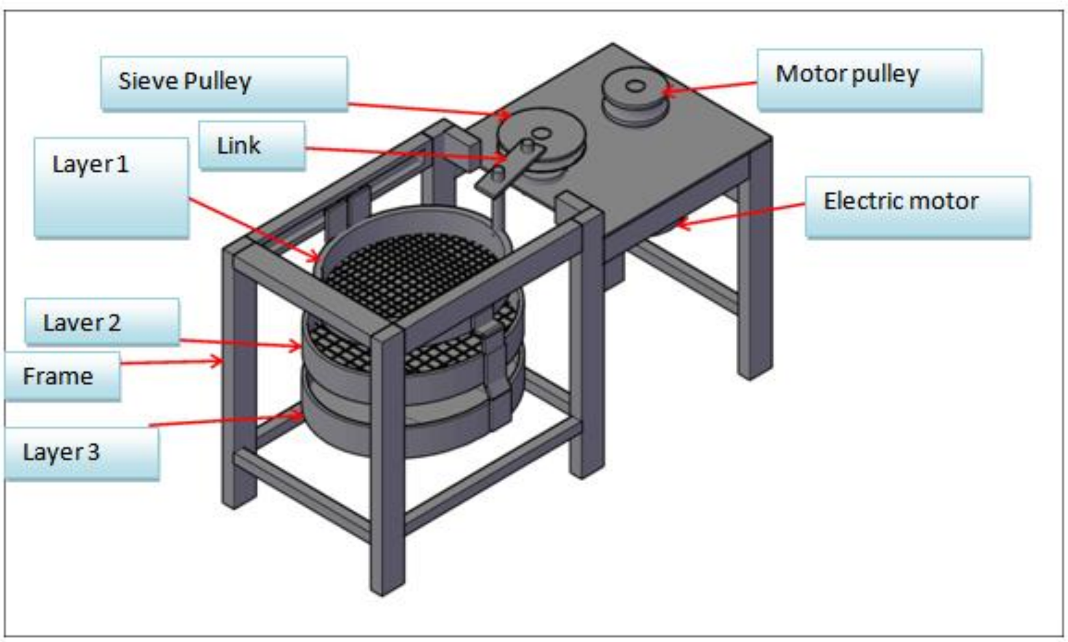

Figure 1: Isometric view of the fabricated machine

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Principle of Operation

Operation of the machine is easy and requires only one individual to operate it easily. Separation by sieving mechanically is accomplished by powering the electric motor which has a pulley; a rubber is attached to the pulley of the motor and then to the bearings which makes up the drive mechanism that goes to and fro along the frame. The motion of the bearings to and fro subjects the mesh assembly to the same, thereby unsettling the materials on the mesh. The constant random motion of these materials and the effect of gravity forces smaller particles that can pass through the mesh to fall through to the lower layer. The particles with the smallest sizes end up at the lowest layer, while those with the largest particle sizes remain on the utmost layer.

Performance Test

A performance test was carried out on the TLESM in the Federal College of Forestry, Jericho, Ibadan. For this study, a mixture of rice, beans and yam flour was separated. This mixed food materials were poured in the first layer of the mesh assembly and sieved. The time to completely separate the mixture into the three different layers was recorded and the respective weight of each layer was finally measured. The experiment was replicated five (5) times. Sieving experiment was further carried out while varying the motor speed and the results were also recorded.

Evaluation Parameters

The triple layer electrical sieving machine was evaluated considering the following factors; workability, weight change, mean-efficiency and the effect of speed change.

Workability … this ascertains if the machine works and separates food materials of different sizes successfully.

Weight change (kg) … this is the difference in the weight input and the output of respective food materials for corresponding layers of the sieving machine.

Mathematically

Weight change = W1 - W2

Where W1 … expected weight

W2 … sieved weight

Mean efficiency (%) … this is the ratio of the mean change in weight of to the expected weight for each layer of mixed food materials on the machine in percentage.

Mean efficiency = $\Delta W/W \times 100$

Where ΔW … mean change in weight

W … expected weight

Speed change (m/s) …. This study further varied the speed of the machine to determine the effect of change in speed on the efficiency of the machine.

III. RESULT AND DISCUSSION

Results

Workability ... the machine was able to perform the specific function of separation; It was able to sieve particles of different shapes and sizes, it can be easily assembled and modified, it can be easily transported to different locations and the parts can be easily maintained or replaced.

Weight change (%) … Table 1 below shows the result of weight change for each layer after five (5) minutes of using the electric sieving machine. Replicate 1 of layer 1 had the highest positive change in weight of +0.5kg, while replicate 5 of layer 3 had the lowest weight change of -0.6kg. Layer 1 had a mean weight gain of 0.42kg; layer 2 had a mean weight gain of 0.14 while layer 3 had a mean weight loss of 0.56kg.

Table 1: Result of different layers after sieving for five (5) minutes

Replicates	Weight of mixture (kg)	Weight change (first layer after sieving) (kg)	Weight change (second layer after sieving) (kg)	Weight change (third layer after sieving) (kg)
1	15	+ 0.5	-0.1	-0.4
2	15	+1	0	-1
3	15	+0.3	+0.2	-0.5
4	15	0	+0.3	-0.3
5	15	+0.3	+0.3	-0.6
MEAN	**15**	**0.42**	**0.14**	**-0.56**

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Table 2 below shows the result of weight change for each layer after seven (7) minutes of using the electric sieving machine. Replicate 5 of layer 2 had the highest weight gain of 0.6kg, while replicate 5 of layer 3 had the lowest weight change of -0.6kg. Layer 1 had a mean weight gain of 0.1kg; layer 2 had a mean weight gain of 0.18 while layer 3 had a mean weight loss of 0.28kg.

Table 2: Result of different layers after sieving for seven (7) minutes

Replicates	Weight of mixture (kg)	Weight change (first layer after sieving) (kg)	Weight change (second layer after sieving) (kg	Weight change (third layer after sieving) (kg)
1	15	+0.2	0	-0.2
2	15	-0.2	+0.3	-0.1
3	15	+0.2	+0.3	-0.5
4	15	+0.3	-0.3	0
5	15	0	+0.6	-0.6
MEAN	**15**	**0.1**	**0.18**	**-0.28**

Table 3 below shows the result of weight change for each layer after ten (10) minutes. Several of the replicates had a weight change of 0.1; the first layer had a mean weight gain of 0.06 kg, second layer had mean weight gain of 0.02 while the third layer had a mean weight loss 0.08.

Table 3: Result of different layers after sieving for ten (10) minutes

Replicates	Weight of mixture (kg)	Weight change (first layer after sieving) (kg)	Weight change (second layer after sieving) (kg	Weight change (third layer after sieving) (kg)
1	15	+0.1	-0.1	0
2	15	+0.1	0	-0.1
3	15	+0.1	+0.1	-0.2
4	15	+0	0	0
5	15	+0	+0.1	-0.1
MEAN	**15**	**0.06**	**0.02**	**-0.08**

Figure 2 below further illustrates graphically, the mean weight changes for the respective time as reported in table 3 above.

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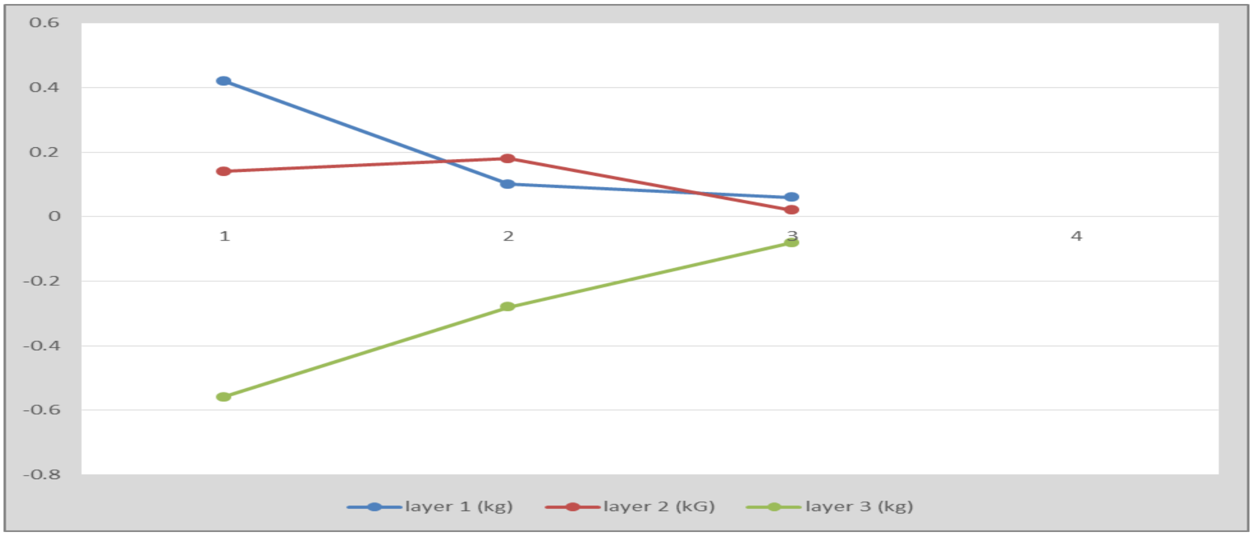

Figure 2: Comparison of the mean weight change after 5 mins, 7mins and 10 mins

Mean efficiency … Table 4 shows the mean efficiencies of the machine for the respective layers at the different time ranges; mean efficiency was as high as 99% in all the layers when sieving operation was carried out for 10 minutes and lowest at 96% for layer 3 when the machine ran for five (5) minutes. This suggests that the longer the machine runs, the more efficient it becomes.

Table 4: Mean efficiency (%)

	5 minutes		**7 minutes**		**10 minutes**	
Layer	**Mean change (kg)**	**Mean efficiency (%)**	**Mean change (kg)**	**Mean efficiency (%)**	**Mean change (kg)**	**Mean efficiency (%)**
1	0.42	97	0.1	99	0.06	99
2	0.14	99	0.18	99	0.02	99.9
3	-0.56	96	-0.28	98	-0.08	99.5

Figure 3 below is a graphical illustration of table 4, showing the effect of increasing the time range for sieving on the mean efficiency of the machine in each layer.

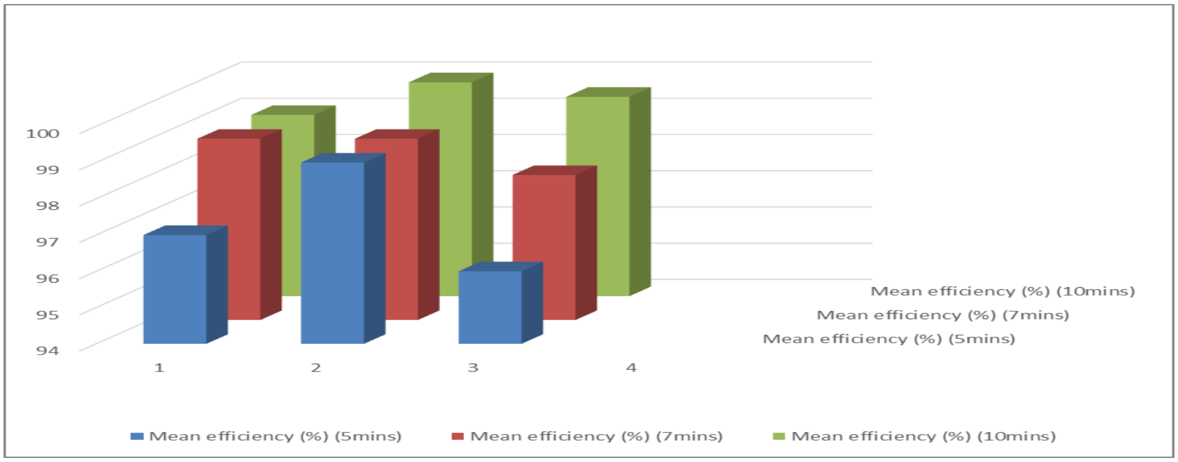

Figure 3: Effect of time increment on the efficiency of the machine

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Effect of change in speed on efficiency … Table 5 is the result of further performance tests to determine the efficiency of the machine when the speed was varied. It showed that when the speed was reduced by half to 300rpm; it had a maximum efficiency of 87% when run for 10 minutes, at a speed of 750rpm; it was observed that the efficiency values were very close to those of speed 600rpm. This implies that, a speed of 750 rpm would also be suitable in standardizing the machine. While speed 1200rpm, it was observed that the sieving process had a lot of vibrations and food crops were been lost as they were falling off the sieving trays of the mesh assembly. Efficiency was as low as 40% at the first replicate in seven (7) minutes and had a maximum efficiency of 51% in the third replicate in ten (10) minutes.

Table 5: Mean efficiency at varying speeds

	300rpm			**750rpm**			**1200rpm**		
Layer	**5min**	**7min**	**10min**	**5min**	**7min**	**10min**	**5min**	**7min**	**10min**
1	85	85	87	96	97.5	99	45	40	46
2	80	84	85	99	99	99.9	54	50	45
3	85	85	87	97	98	99.5	47	46	51

IV. CONCLUSION

The machine was able to perform the specific function of sieving and separating food materials of varying sizes. The machine passed the test of workability. Mean efficiency was high when sieving operation was carried out for 10 minutes; this could be because the machine had longer time to run, hence particles had more time to settle down on the layer designed for their respective sizes; these suggest that the longer the machine runs, the more efficient it becomes. In the present age, separation of different sizes of solid material needs to be done properly considering time taken. This project can be used for separation of different sizes of solid only by changing mesh of required size (Saritha *et al*., 2014). Further performance tests showed that a decrease in the speed of the machine would to reduce the efficiency.

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