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Influence Of Screen Speed And Air Velocity On The Cleaning Efficiency Of A Cowpea Rotary Screen Cleaner

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Abstract

The influence of screen speed and air velocity on the cleaning efficiency of a rotary screen cleaner was investigated. The efficiency of separation of clean grain (ξ_G) efficiency separation of material other than grain (ξ_{MOG}) total cleaning efficiency (ξ_T) and percentage purity ($\%P_P$) were evaluated at air velocities of 0.3, 1.3, 2.2, 2.7 and 3.5 m/s and screen speed of 115, 145, 200, 280 and 315 rpm using two varieties of cowpea namely IT90K-277-2 and Ife brown. The results showed that ξ_G decreased with increase in air velocity and screen speed while ξ_{MOG}, ξ_T and $\%P_p$ increased with increase in air velocity and screen speed for the two varieties. The highest values of ξ_{MOG}, ξ_T and $\%P_p$ for the two varieties were obtained at air velocity of 3.5 m/s and screen speed of 315 rpm.

INTRODUCTION

Cleaning is an important post harvest operation that is aimed at removing impurities or contaminants from harvested grains. It is an indispensable operation before drying, storage, marketing or further processing of the products. Clean and homogenous grains attract a high premium, resulting in high profit from sales to farmers. Cowpea (*Vigna unguiculata* (L.) Walp) is an annual legume that is widely grown and consumed in Nigeria. It has been observed that freshly harvested and threshed cowpea in Nigeria contains between 27-33% impurities and this poses threat to human consumption and large scale agricultural processing (Adetunji, 2012). *This has necessitated the development of cleaning machines such as rotary screen cleaner for removing impurities from cowpea (Aderinlewo and Adetunji, 2013)*

Several researchers have developed different cleaning machines for different grains such as air-screen cleaner for beniseed (Akinoso et al. 2010), continuous flow cowpea cleaner (Aguirre and Garay, 1999), reciprocating screen cereal cleaner (Okunola and Igbeka, 2009), Chickpea cleaner (Tabatabaeefar et al. 2003), air screen cleaner for rice (Pasikatan, 1996), rasp-bar sorghum thresher cum cleaner (Simonyan and Yiljep, 2008), rotary screen cleaner for cowpea (Aderinlewo and Adetunji, 2013). Most of these researchers reported that cleaning on these machines is influenced by factors such as air velocity, injection angle, amplitude and frequency of oscillation of sieves. However, for rotary screen cleaners information on the influence of screen speed and air velocity on cleaning of cowpea is scarce.

This work was therefore carried out to investigate the influence of screen speed and air velocity on cleaning efficiency of a rotary screen cowpea cleaner.

MATERIALS AND METHOD

The materials used for this work include two freshly harvested varieties of cowpea namely IT90K-277-2 and Ife brown and their impurities obtained from Institute of Agriculture research and Training, Ibadan and a rotary screen cowpea cleaner developed at the Department of Agricultural Engineering, Federal University of Agriculture, Abeokuta. The moisture content of the cowpea varieties were determined by oven drying method and

were found to be 12.4% wet basis.

Description of the rotary screen cleaner

The rotary screen cleaner consists of three main components namely a hopper, a centrifugal blower and a rotary screen. The hopper was fitted above the rotary screen. The centrifugal blower was positioned between the hopper and the rotary screen so that light weight impurities can be blown away before entering the rotary screen. The centrifugal blower was made of three plates attached to a bracket mounted on a shaft. It was driven by a 1 horse power, 960 rpm electric motor which also powers the rotary screen. The rotary screen is of diameter 300 mm and length 500 mm. The screen opening is circular and is of diameter 6 mm.. Power transmission was by V-belt and pulley arrangement. The isometric view is shown in Figure 1.

Determination of Cleaning Efficiency

Each of the two varieties of cowpea was contaminated with the impurities to a level of 10 %. 240g each of the mixture of sound grain and impurities were injected into the rotary cleaner at different air velocities and screen speeds. This was replicated three times. On each occasion the separation efficiencies of the machine were evaluated using the indices reported by Igbeka (1984) as follows:

Efficiency of separation of cleaned Cowpea, ξ_G

This efficiency was obtained as the ratio of cleaned cowpea grain coming out of the clean-grain outlet to the total clean cowpea grain fed into the machine.
Mathematically:

$$\xi_G \frac{GP}{GP + GR}$$

where; GP is the weight of clean cowpea in the clean-grain outlet, *g*, and

GR is the weight of clean cowpea grain in the reject outlets, *g*

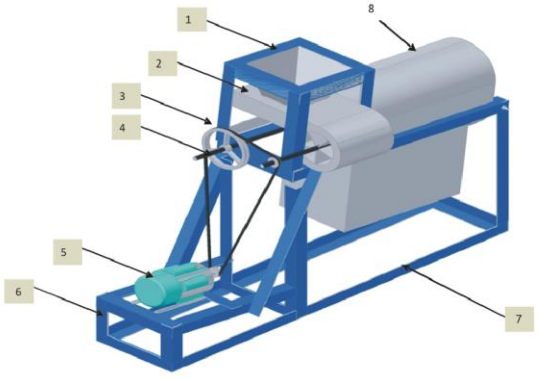

FIGURE 1: The Rotary Screen Cleaner

1: Hopper or Inlet, 2: Air duct, 3: Pulley, 4: V-belt, 5: Electric motor, 6: Motor stand, 7: Main frame, 8: Screen Case

Efficiency of separation of MOG (material other than cowpea), ξ_{MOG}

This efficiency was obtained as the ratio of the weight of MOG (which includes chaffs, broken and under-matured cowpea grains) to the total weight of the MOG fed into the machine.

This efficiency is represented mathematically as follows:

$$\xi_G \frac{BR}{GR + GP}$$

where; BR is the weight of MOG collected from but reject outlets, *g*, and

BP is the weight of MOG collected in the clean-grain outlet, *g*.

Total Cleaning Efficiency of the machine, ξ_T

This was obtained as the product of the efficiency of separation of good product and the efficiency of separation of MOG.

This is also expressed mathematically as:

$$\xi_T = \xi_G = \xi_{MOG}$$

where; ξ_G and ξ_{MOG} are as described earlier.

Percentage purity of whole cowpea grains in products, $\%P_p$:

This was obtained as the ratio of weight

of whole cowpea grains in the products to the total weight of products.

This is expressed mathematically as:

$$\%_P \frac{GP}{GP + BP}$$

The average values of efficiencies of separation of cleaned grains, ξ_G, separation of materials other than grain, ξ_{MOG}, total cleaning efficiency, ξ_T, and percentage purity $\%P_p$ obtained for the two varieties of cowpea are presented in Tables 1 and 2. It was observed that ξ_G decreased with increase in air velocity and screen speed while ξ_{MOG}, ξ_T, and $\%P_p$ increased with increase in air velocity and screen speed for the two varieties.

Table 1. Separation efficiencies for IT90K-277-2

Screen speed, rpm	Air velocity, m/s	ξ_G, %	ξ_{MOG}, %	ξ_T, %	$\%P_P$ %
115	0.3	98.52	27.59	26.89	91.29
145	1.3	97.33	50.16	48.81	93.79
200	2.2	95.16	57.64	54.85	94.56
280	2.7	94.03	65.20	61.31	95.44
315	3.5	93.04	68.89	64.09	95.86

Table 2. Separation efficiencies for Ife brown

Screen speed, rpm	Air velocity, m/s	ξ_G, %	ξ_{MOG}, %	ξ_T, %	$\%P_P$ %
115	0.3	98.94	39.39	38.98	92.66
145	1.3	97.98	57.94	56.77	94.16
200	2.2	96.20	61.92	59.56	95.13
280	2.7	94.67	66.73	63.32	95.67
315	3.5	93.87	71.12	66.76	96.18

The highest efficiency of separation of cleaned cowpea grain obtained for IT90K-277-2 was 98.52% at screen speed of 115 rpm and air velocity of 0.3 m/s. The highest efficiency of separation of MOG, total cleaning efficiency and percentage purity are 68.89, 64.09 and 95.86% respectively at screen speed of 315 rpm and air velocity of 3.5 rpm.

For Ife brown, the highest efficiency of separation of cleaned cowpea grain was 98.94% at screen speed of 115 rpm and air velocity pf 0.3 m/s. The highest efficiency of separation of MOG, total cleaning efficiency and percentage purity are 71.12, 66.76 and 96.18% respectively at screen speed of 315 rpm and air velocity of 3.5 rpm.

Figs. 1 and 2 show the variation of efficiency of separation of material other than grain (MOG) with screen speed and air velocity respectively for IT90K-277-2. It can be seen that as the screen speed increased from 115 to 315 rpm and air velocity increased from 0.3 to 3.5 m/s, ξ_{MOG} increased from 27.59 to 68.89%.

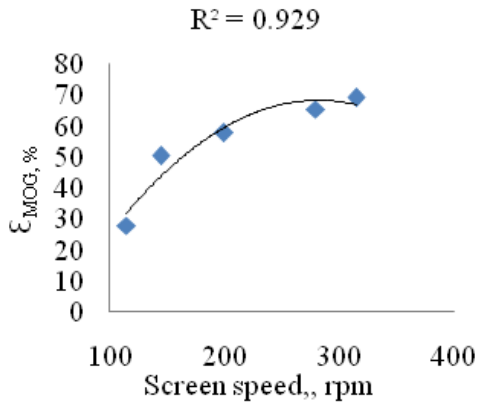

Fig.1: ε_{MOG} Vs screen speed

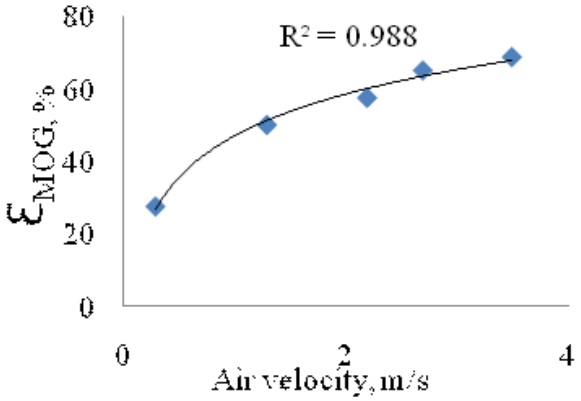

Fig. 2: : ε_{MOG} against air velocity

The variation of ξ_G, with screen speed and air velocity for Ife brown is shown in Figs. 3 and 4 respectively. As the screen speed increased from 115 to 315 rpm and air velocity increased from 0.3 to 3.5 m/s, ξ_{MOG}, increased from 39.39 to 71.12%.

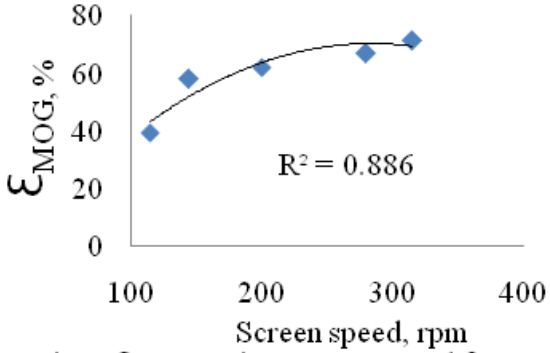

Fig.3: ε_{MOG} against screen speed for Ife brown

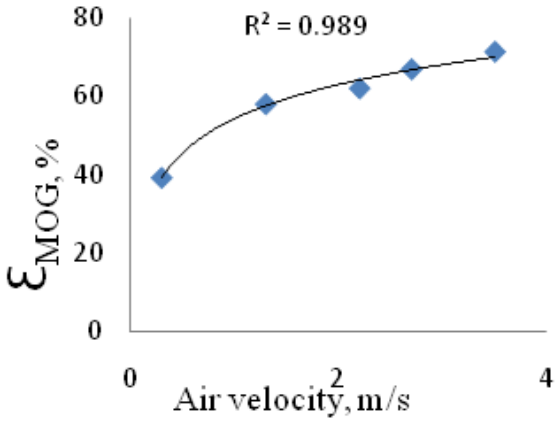

Fig.4: ε_{MOG} against air velocity for Ife brown

CONCLUSIONS

1. The efficiency of separation of clean grain decreased with increase in screen speed and air velocity and the highest values of 98.52 and 98.94% was obtained at screen speed of 115 rpm and air velocity of 0.3 m/s for the two cowpea varieties.

2. The efficiency of separation of MOG, total cleaning efficiency, and %purity of increased with increase in screen speed and air velocity and the highest values were 68.89, 64.09, 95.86 and 71.12, 66.76 and 96.18% respectively for IT90K-277-2 and Ife brown obtained at screen speed of 315 rpm and air velocity of 3.5 m/s.

3. Further cleaning by re-introducing the mixture of the two varieties into the machine increased all the various efficiencies and produced a %purity of 100%.

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