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PERFORMANCE EVALUATION AND MODIFICATION OF THE IPHT FINGER MILLET DE-STONING MACHINE

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Abstract

A study was carried out to modify the finger millet (Kurakkan) De-Stoner, developed by the Institute of Post-Harvest Technology in Sri Lanka (IPHT) for separation of the grains from foreign materials and stones, based on the principle of difference in velocities of motion between the finger millets and stones on a rough inclined plane. The modification was carried out on re-designing of the machine supports and adjustment devices, reconstruction of collecting hoppers and feeding hopper, construction of a wiping brush and two supporting rollers for the inclined plane. Performance of the modified machine was evaluated by determining its capacity, separation efficiency, power transmission efficiency, power consumption, cost of separation and total cost of machine. This modified machine has a capacity of 12kg/hr. at the optimum speed of 30rpm and 10-degree angle of the separating surface (conveyor belt) and cost of separation is Rs.2.10/kg. The de-stoning efficiency of machine during the first, second, and third passes is 86.34%, 89.34%, and 94.47% respectively. The power consumption of the machine is 0.69kw and power transmission efficiency of machine is 96%.

Key words: *Velocities of motion, Incline plane, Feeding and collecting hoppers, Power transmission and consumption efficiency, De-stoner efficiency.*

Introduction

Finger millet is an important subsidiary food crop cultivated in Sri Lanka and its domestic production is approximately 4500 metric tons per annum. The growing condition of fingermillet is suitable to Sri Lanka climate. It is one of the main sources of food, when rice is in short supply. The grains are grind into flour, which is use for Pittu, Roti, Thalapa and Sweetmeats and also these foods are very useful especially for diabetic patient.

A major problem confronting the finger millet industry in Sri Lanka is high percentage of impurities present in grain produced by farmers. Therefore, cleaning is one of the most important aspects in post-harvest processing. Cleaning of seeds is termed as a material separation process. The objective of this process is to separation undesirable stones and foreign materials from seeds and obtain clean seeds for better storage and quality processing.

Traditional method of cleaning finger millet is hard, tedious and labour consuming. Also, modern methods, which use high technology, are very expensive. Therefore, a cost-effective device must be developed and evaluated for separating finger millet and stones, which is suitable for small and medium scale producers.

In Sri Lanka there has been a growing awareness and increasing demand for better quality finger millet "*Kurakkan*" especially for de-stoned seeds. An essential component of a quality improvement programme is development of appropriate processing techniques to produce high quality *Kurakan.* In this regard, introducing cleaning devices, which could separate all foreign matter from *Kurakkan* is of a great importance because presence of any foreign matter results in a considerable reduction in the quality. Therefore, high demand for seed cleaning machine, especially for *Kurakan.* The main type of impurities in finger millet are often sand and stones, and the most of sand particles are same size as the finger millet. Normal sieving using different sieve sizes cannot separate same size particles. Therefore, surface properties (friction co-efficient) of finger millet grains and sands were used as separating parameter.

This research study was conducted to modify the finger millet de-stoner, which was developed by the Institute of Post-harvest Technology in Sri Lanka to separate the grains from stones and foreign materials based on the principle of difference in velocities of motion between finger millet and stone on a rough incline plane in order to optimize its performance.

Objective of the study

1) To modify and develop the IPHT low-cost finger millet De-stoner to improve its cleaning efficiency.
2) To test and evaluate the performance of the modified De-stoner by determining the following: Machine capacity, De-stoning efficiency, Power transmission efficiency, Power consumption and Cost evaluation of De-Stoner.

Materials and methods

IPHT Finger millet De-Stoner and its operation features.

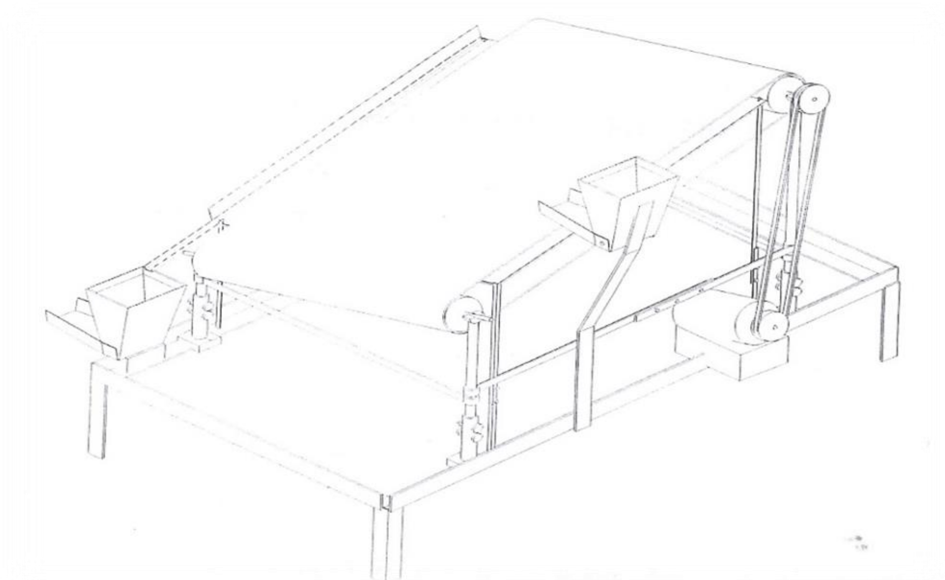

Figure.1 IPHT Finger millet De-Stoner before modification.

The IPHT Finger millet De-Stoner shown in 3.1 figure was fabricated at the Institution of Post-Harvest Technology. But it had still poor efficiency and operational issues.

The following problems were identified.

a) It has shown very low separation efficiency of grains from stones.
b) The separation surface of convey belt overlapping the lower edge of the rollers during running operation.

c) The De-Stoner machine hasn't proper adjustments to optimize it's running efficiency.

Modification of the machine.

After a thoroughly inspection study identified that machine is required modifications to improve its performance and efficiency. Therefore, the research done following modification.

1. Adjustable supporting Legs

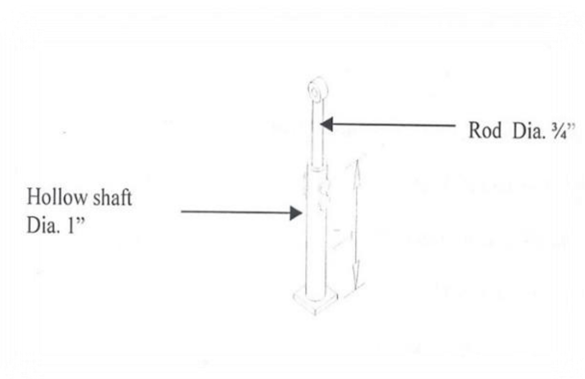

Figure.2 Adjustable supporting Legs

A rod and hollow shaft assembled for supporting its 4 legs.

Material specification

Rod connected with bearing – ¾'' Ms iron bar (height according to drawing) and Hollowshaft – 1'' GI pipe (height according to drawing).

The method of fabrication:

A rod cut according to dimensions by using Hacksaw. A bearing was joint to rod using Electric arc welding.Hollow shaft was cut according to above dimension by using Hacksaw and drilling machine for making holes (Diameter-0.124inch) on the hollow shaft.A nut(inner diameter 0.125inch) was welded on the face of that hole by Electric arc welding.

2. Adjustment device

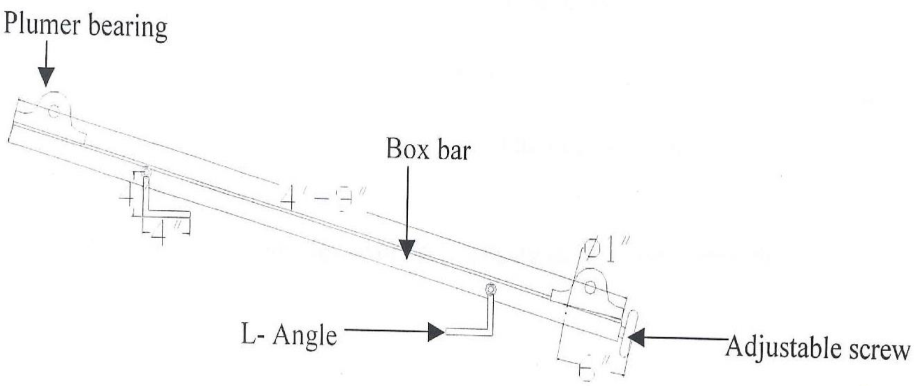

Figure.3 Adjustable device

Material specification

Box bar 1.5’’ square bar, thickness length 4mm, Adjustable screen wheel 6’’ bolt and nut thickness 12mm, Langle 4’’ X 4’’

The method of fabrication:

Two box bars were used with the size of 5’ but ends have two adjustable screw.it is using for change the drum roller angle with horizontal plane as a result belt inclination can change.Four “L” angle have joint with flexible joint on the box bar.Two adjustable screws were fixed at rear side of the box bar end to control side moveme

3. Supp elt

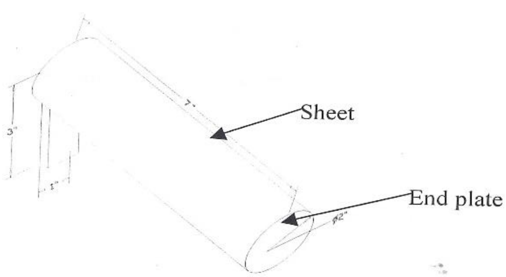

Figure.4 Supporting roller

Material specification

Drum cover mild steel sheet gauge 16, shaft nut and bold length 6'' diameter 5mm, two end plates mild steel plates diameter 4'' and thickness 0.25''

The method of fabrication

The drum cover was done by rolling machine was used to roll the sheet and the straight edge was welded by using oxy-acetylene gas welding. The shaft made by two nut and bolt for machine turning operation. Two end plates make by oxygen acetylene gas metal cutting and turning operation were used for construct.

4. Feeding hopper

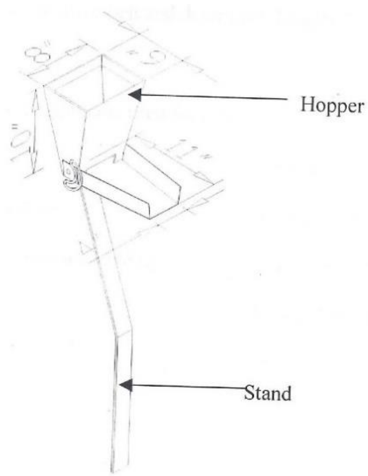

Figure.5 Feeding hoper

Material specification

Feeding hopper mild steel (gauge 16'')

The method of fabrication

Hand shear machine was used for cutting plate according to dimension in the drawing and oxygen acetylene gases welding for assembled. Feeding hopper had an adjustment to control the feeding rate and it can move horizontal and vertical plane, it helps to change the feeding position on the conveyor belt and determine the gravity force of grains.

5. Collecting hoppers

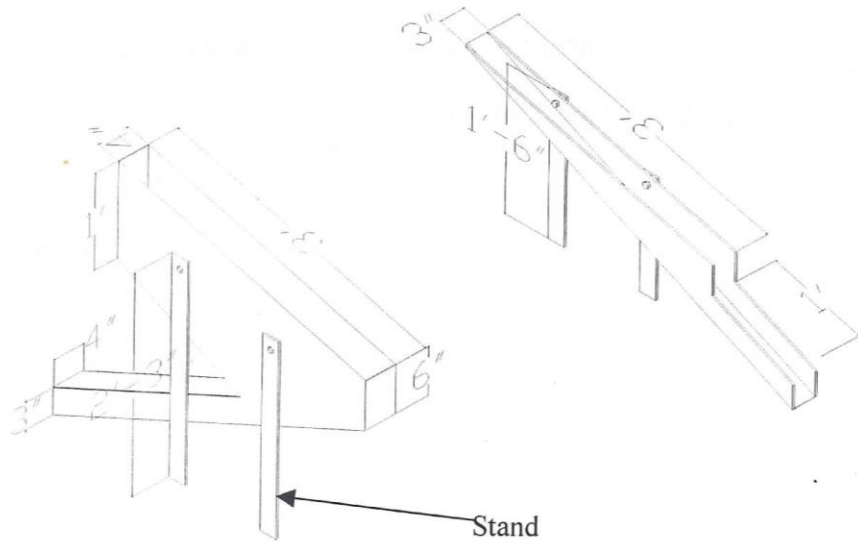

Figure.6 Collecting hoper

Material specification

Two collecting hoppers were constructed to collect the separated grains and stones. One was mounted at top level of conveyor for collect the stones and another was sited for collect the grains.it was mild steel(gauge16'').

The method of fabrication

Hand shear machine was used for cutting plate according to dimensions in the drawing and oxygen acetylene gases welding for assembled.

6. Wiping brush

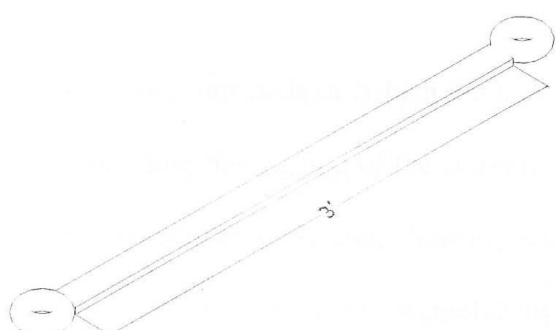

Figure.7 Wiping brush

Material specification

Wooden brush length 3’’ width 2’’ and thickness 0.5’’.

The method of fabrication

A wooden brush was fixed at the top of the conveyor edge at the front side of the machine. It was wiping the stones and foreign matter; it helps to conform the clean conveyor belt motion.

Assembling of modified De-Stoner

Two drum rollers, four pods which height could be adjustable, two support rollers for avoiding the sagging of the conveyor belt, box bar, L angle, Adjustable screw, feeding hopper, collecting hopper, supporting structure, variable speed electric motor and pulleys were assembled by using nuts and bolts. Power was given by variable speed electrical motor with using transmission belt to rotate the rum roller.

Design and operation features of the modified finger millet De-Stoner.

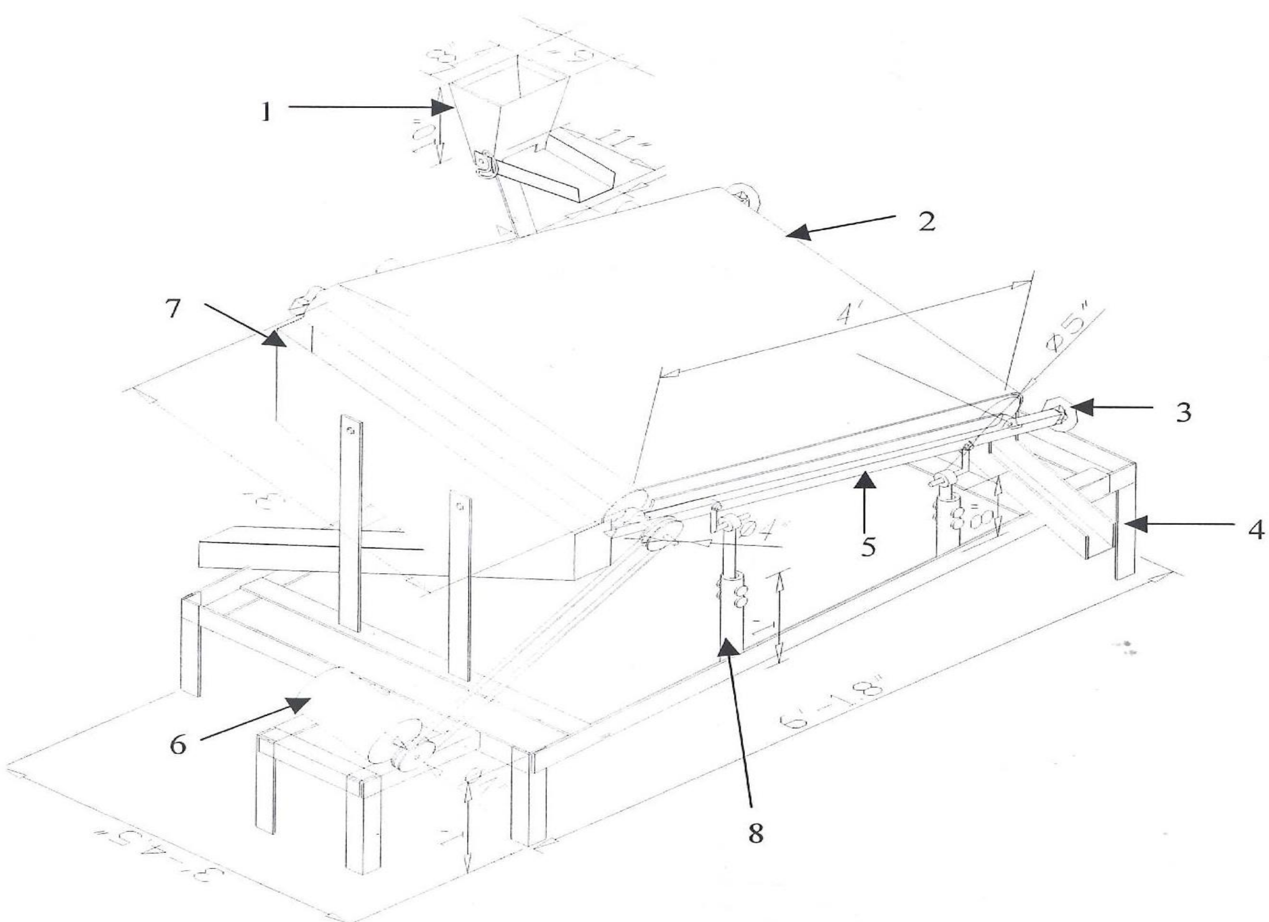

Figure.8 Modified finger millet De-Stoner.

The main types of impurities present in finger millet are often sand and stones. The most of sand particles are often same size as the finger millet. And hence, normal sieving using different sieve sizes cannot separate these particles. Therefore, surface characteristic method must be got use for it. Clear difference can be found between surface properties (friction co-efficient) of finger millet grains and sand.

The operation of the separation is based on the different between velocities of two particles, which have two different friction co-efficient, and have zero initial velocities we can identify the velocity difference of two particles and difference between their current positions.When finger millet and stone mixture was fed into the feeding hopper the hopper can control the feeding rate. Also, initial velocity of finger millet and stones particles were different on the conveyor belt. When conveyor belt was running the mixture of finger millet and stones were separated.

The round particle has low friction, so they become down wards, Unround particles have high friction, so they were traveled upward. The angle of conveyor belt can change by pods adjustments, until to increase the de-stoning efficiency. The adjustment structure used to control the conveyor belt position.

The power supplied by variable speed electric motor. The speed different between 10 to 350rpm.Two pully and "V" belt were used to power transmission. The electric motor able to adjust angle wise and horizontal, according to the suitable aliment. Power is transmitted through a V-belt. Three variable rum speed(rpm) and three suitable conveyor belt angles of machine were selected through preliminary testing trails.

Sample selection and preparation

The fresh harvest grains were selected for the experiment. The test was performed at grains maturity stage at moisture 8.3% and normal temperature 32^{o}C.

200g pure finger millets was taken and it was mixed well with 100g same size stones which was obtain by using 1/15 sieve size. This millet stones mixture was divided in to three portions, which was considered as three replicates. So, one potion mixture contains 100g.

Experimental design for evaluate De-Stoner

Two factor factorials statically design was selected to evaluate the machine performance. Each treatment had three replications. The data obtained from the preliminary testing trail. The data were statistically analyzed, using the SAS, statistical package to test the significance.

Evaluation procedure

The capacity of the de-stoner machine at different drum speed was determined by taking the de-stoning experiment time. The weight of the samples was measured by electronic balance. The electronic balance was used to take the weight of the grains and stones samples must have accuracy to two decimal points.

Results and Discussion

The performance of the IPHT de-stoner in terms of capacity, de-stoning efficiency, power transmission efficiency, power consumption and cost of separation were evaluated. The de-stoning efficiency was evaluated against different drum speeds(rpm) and different angles of conveyor belt (separating surface). The data obtained from the testing trail were statistically analyzed using the SAS, statical package for the test of significance.

1. Machine capacity

The capacity of the de-stoner(kg/hr.) was calculated by using the following equation. The feeding rate was maintained as constant throughout the test.

Capacity (kg/hr.) = Weight of the inputs(g) X 3600

$$= \frac{100\text{g X } 3600}{30\text{ (sec)}}$$

$$= 12\text{kg/hr.}$$

2. De-Stoning efficiency (%) of the machine.

The de-stoning efficiency was calculated by using the following equation and the results are given,

$$\text{De-Stoning efficiency (\%)} = \frac{\text{Initial weight of mixture – final weight of mixture X 100}}{\text{Initial weight of mixture}}$$

Table 1: De-Stoning efficiency in different angle (degree)

Angle	Mean
9	0.44475c
10	0.75294a
11	0.66787b

The mean with the same letter is not significantly different according to Duncan Multiple range test at 0.05 level.

Table 2: De-Stoning efficiency in different speed(rpm)

Angle	Mean
20	0.59760b
30	0.77670a
40	0.49810c

The mean with the same letter is not significantly different according to Duncan Multiple range test at 0.05 level.

Table 3: De-Stoning efficiency in different angle Vs speed combination

Angle * Speed combination	Mean	Average De-Stoning Efficiency
10*30	1.04221 a	86.34
11*30	0.82428 b	73.39
10*20	0.66589 c	61.76
11*20	0.66549 c	61.72
10*40	0.55072 d	52.24
11*40	0.51385 d	49.06
9*30	0.46362 de	44.66
9*20	0.44091 de	42.61
9*40	0.42973 e	41.51

The mean with the same letter is not significantly different according to Duncan Multiple range test at 0.05 level.

Based on the evaluation results, 10-degree angle and 30 rpm combination were selected as the best optimal adjustment point of De-stoner machine.

This machine efficiency tested at constant 10-degree angle and 30 rpm combination. Three replications were taken to check this point. At 1st passing efficiency was 86.34%, 2nd passing efficiency was 89.34% and 3rd passing efficiency was 94.47% respectively.

3. Power transmission efficiency (%) of the machine.

The power transmission, which was calculated by using the following equation and th result are summarized.

Practical speed of conveyor drum = 29

Theoretical speed of conveyor drum = 30

= 29/30X 100

= 96%

Table 4: Power transmission efficiency in different speed(rpm)

Different speed(rpm) constant Angle at 10 (degree)	Mean
20	1.571a
30	1.287b
40	1.253c

The mean with the same letter is not significantly different according to Duncan Multiple range test at 0.05 level.

4. Power consumption of the machine.

The power consumption, which was calculated by using the following equation and results are summarized.

$P = \sqrt{3}\ VI \cos Ø$

P = Power consumption

V = Voltage

I = Ampere

$\cos Ø = 0.8$

$P = \sqrt{3} \times 415 \times 1.2 \times 0.8$

$= 690.04$ W

Table 5: Power consumption in different speed(rpm)

Different speed(rpm) constant Angle at 10 (degree)	Mean
20	1.571a
30	1.287b
40	1.253c

The mean with the same letter is not significantly different according to Duncan Multiple range

Power consumption at 10-degree angle and different speed(rpm). The machine power consumption is 0.69KW at suitable angle 10degree and speed 30rpm.

Conclusion

The IPHT finger millet de-stoner machine is a practicable low-cost device for finger millet de-stoning operation, and it has the capacity of 12kg/hr. The recommended speed and angle combination of de-stoner cleaning surface is 30rpm speed and 10degree angle. Three test passes have been carried out to check its efficiency. The first, second and third passes calculated efficiencies are 86.34%, 89.34% and 94.47% respectively. The power requirement for operating the de-stoner is 0.69 kw. The power transmission efficiency is 96%.

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