

Research Paper :

Ergonomical study and performance evaluation of different types of coconut dehuskers

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Received : December, 2010; Accepted : January, 2011

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ABSTRACT

The performance and ergonomical study of a power operated coconut dehusker and other manually operated coconut dehuskers was carried out at College of Agricultural Engineering and Technology, OUAT, Bhubaneswar for its suitability among the farmers on the basis of dehusking efficiency and ergonomical considerations like heart rate, oxygen consumption rate etc. during operation. Dehusking of coconut is a very tedious job and many of the labourers show reluctance for this work as it causes injury to them by following traditional method. Development of a suitable coconut dehusker is, therefore, very much important in the state Odisha where there is a great potential for coconut cultivation and marketing of commercial products like copra and coir from coconut husk. Hence, the aim of the study was to develop a power operated coconut dehusker which would become safe and easy to operate, simple to fabricate, commercially feasible and economically viable compared to other manually operated coconut dehuskers. It was observed that the power operated dehusker worked well in terms of number of nuts dehusked per hour, dehusking efficiency, cost of use and with ergonomical considerations.

Ghosal, M.K. and Mohanty, S.K. (2011). Ergonomical study and performance evaluation of different types of coconut dehuskers. *Internat. J. Agric. Engg.*, 4(1) : 45-51.

Key words : Coconut dehusking, Coconut dehusker, Dehusking efficiency, Ergonomics

Dehusking is the process of removing the outer covering called husk from the coconut to get two important commercial products such as copra or dried kernel and fibre or coir. Copra yields oil and oil cake where as fibre produces carpets/mattresses and coir pith briquettes. Coconut shell obtained after dehusking is also a very useful industrial product to get coconut shell charcoal, activated carbon and coconut shell powder which have a good market value (Jacob and Bastian 1998). Dehusking is, therefore, an important operation for coconut processing industry. The coconuts reaching markets are either partially husked or dehusked as per demand and requirement in distant markets. Coconuts meant for copra making are fully husked. Coconuts meant for distant market places are left with some fibres covering the eyes or on all around the nuts. Such partially husked coconut minimizes the breakage during transportation and attains longer keeping quality. It is also observed that even when coconuts are fully husked, a tuff of husk is left at the end of the nut over the eyes as it is considered to be auspicious and believed to preserve the nuts from spoilage. It has been reported that about 20 per cent of the total coconut produced in Odisha are consumed as tender nuts and 5

per cent are retained by the farmers for household and seed nut purposes (Anonymous, 2007). About 42 per cent of the coconut produced is consumed in the state itself and 33 per cent are exported to the other states like Bihar and Madhya Pradesh where cultivation of coconut is not favourable. Hence, dehusking of coconut needs to be done not only to increase the bulk density for easy transportation but also to process quickly for industrial purposes. Mechanization of dehusking operation is needed in the state like Odisha as coconut is one of the most important plantation crops of the state. The area under coconut production in the State is about 43.3 thousand hectares producing 296.05 million nuts. The present productivity of the crop has been reported to be 8741 nuts per hectare as against the productivity of 6285 nuts per hectare in India (Anonymous 2004).

The most frequently used dehusking method in the state is by the use of pointed metal spike, secured in the ground in a slightly slanting position, with the pointed ends upwards (Mishra and Sutar 2007). The nuts are brought down with force on the spike, followed by twisting the nut sideward against the spike, causing loosening of the husk. Care is taken for the desired entry of the sharp end

of the spike into the husk so as to avoid the damaging of shell. It is, therefore, clear that dehusking is a hard work, and may cause frequent injury to the operator. This job is not very popular as it is often difficult to find labour for this operation due to the every possibility of accidents. It involves a lot of drudgery and needs precaution against injury. Since dehusked coconut is an important material of commerce, dehusking needs to be mechanized and this study has, therefore, been taken up with the following objectives to develop a suitable power operated coconut dehusker, to compare its performance in terms of number of nuts dehusked per hour along with dehusking efficiency with other manually operated coconut dehuskers, to calculate the economics of using various coconut dehuskers and to study the ergonomical assessment of using various coconut dehuskers

METHODOLOGY

Traditional coconut dehusker:

The most frequently used dehusking method in the state is by the use of pointed metal spike, secured in the ground in a slightly slanting position, with the pointed ends upwards. The nuts are brought down with force on the spike, followed by twisting the nut sideward against the spike, causing loosening of the husk. Care is taken for the desired entry of the sharp end of the spike into the husk so as to avoid the damaging of shell. The number of nuts dehusked per hour is around 100. Slight carelessness during operation leads to injury to the operator.

Hand operated coconut dehusker:

It is operated with the help of the hand of the operator. It works in the principle of first class lever. It can dehusk 125 nuts per hour at optimum moisture content



Fig. 1 : Hand operated coconut dehusker

of about 15%. The operator is to bend forward while working which causes discomfort and fatigue within a short period. The technical details of the dehusker and its photograph are given below.

Technical details:

- Base = 12 cm x 12 cm
- G.I pipe (medium) = 30mm dia round rod
- 35 x 5 MS flat
- Knife = 7 cm
- Angle = 25 mm x 25 mm x 5 mm
- Overall dimension = 65cm x 58cm x 20cm

Pedal operated coconut dehusker:

It is a modified form of the hand operated coconut dehusker. Its operation becomes easier compared to hand operated one because of using both the foot as per the requirements of the operator. The women can also operate the dehusker. It can dehusk 170 nuts per hour at optimum moisture content of about 15%. The technical details of the dehusker and its photograph are given below:



Fig. 2 : Pedal operated coconut dehusker

Technical details:

- Height = 50cm
- Base = 38 cm x 38 cm
- Pedal = 6" x 6"
- Rod = 38 cm
- Lever knife = 7 cm

- Shaft = 8 cm spring
- Angle = 25 mm x 25 mm x 3mm
- 40mm x 5 mm M.S. flat nut bolt
- G.I. pipe (medium) = 30mm diameter

Constructional details of power operated coconut dehusker:

A coconut dehusker has been developed which is operated by an electric motor with a reduction unit for actuation of sharp edged metallic fingers (one fixed and other movable) with the help of a movable cam to dehusk the manually fed coconut. The various components of the dehusker are as follows;

- A prime mover-1 hp motor
- Reduction unit (for reducing speed of motor)
- Belt and pulley
- Shaft
- Cam
- Lever and knife
- Hand protecting cover (safety ring)
- Concave chute

The prime mover used for the study is an electric motor of 1 hp capacity running with 1440 rpm and fitted at the bottom of the experimental set up. The reduction unit is used to reduce the rpm of motor to 25 rpm so that coconut can be easily fed to the fingers by their slow movement. Power is available at the pulley connected to

the prime mover. With the help of belt and pulley arrangement, the power is transmitted to the shaft of the coconut dehusker. An idler pulley is used to maintain the belt tension. The pulley at the end of the shaft of dehusker revolves with 15 rpm and the power is finally transmitted to the cam. The cam is attached to the other end of the shaft of the coconut dehusker. This cam transmits the rotary motion to the linear motion of the movable finger through a lever. The two fingers are hinged in such a way that one finger is fixed and other one moves forward and backward periodically to make a separation of approximately two inches between them. After switching on the motor, the operator is to feed the coconut on the sharp edge of the knives when both the knives are closer to each other. When the knives are separated from each other, the husk in the coconut is loosened and then the coconut is again put on the knives when both the knives are closer to each other for second time for further loosening of the husk at the other portion of the nut. This practice is repeated 3-4 times for complete loosening of the husk. Then the loosened coconut is handed over to the helper who is to completely remove the loosened husk from the nut and the nut is now in dehusked condition for its easy transportation and for use in some other purposes. The technical details and photograph of the dehusker is given below:



Fig. 3 : Power operated coconut dehusker



Fig. 4 : Power operated coconut dehusker

Technical details:

- Table:-77cm´96cm´96cm
- Angle:-40mm´40mm´5mm
- 2mm mild steel sheet:-77cm´96 cm
- Electric motor:-1HP, single phase
- V-pulley:-
- Pulley at the shaft (driven):-10²
- Pulley at motor (driving):-6²
- Idler pulley:-5²
- V-belt:-B80
- MS shaft:-64cm length, 2.5cmÆ
- Bearing and bearing housing:-2 Nos
- Knife:-7cm
- Nut bolts:-3/8²
- Cam lift:-13.75cm
- Knife opening:-5cm

Parameters measured to study the performance of dehusker:

The freshly harvested coconuts are generally dried in the sun for 8-12 days to reduce the moisture content suitable for easy dehusking. Before dehusking, a small strip of the husk is removed from any one coconut out of a heap of coconuts harvested at the same time. The removed husk is put inside the oven at 105 °C for 24 hrs for determination of moisture content. Before putting the husk inside the oven, the weight of the husk is taken. Then after 24 hrs, the dried husk is taken out of the oven and weighed again. After that the moisture content of the coconut is calculated. Usually the moisture content (M.C) of a substance is expressed in percentage by weight on wet basis. Moisture content can also be determined on dry basis by the following formulae.

$$\text{M.C. wet basis (W}_b\text{)}\% = \frac{\text{Weight of moist material} - \text{Weight of dry material}}{\text{Weight of moist material}} \times 100$$

$$\text{M.C. dry basis (D}_b\text{)}\% = \frac{\text{Weight of moist material} - \text{Weight of dry material}}{\text{Weight of dry material}} \times 100$$

$$\text{Dehusking efficiency}\% = \frac{\text{Weight of husk obtained after dehusking}}{\text{Weight of total husk present in the coconut}} \times 100$$

At first the husk is weighed after dehusking. Then the remaining husk present in the coconut is removed completely from the dehusked coconut manually to know the total weight of the husk. The dehusking operation was performed continuously for 20 minutes with a rest interval of 10 minutes for providing comfort to the operator. Finally the number of coconuts dehusked per hour is calculated for the same variety and at same moisture content for analysis.

Physiological parameters of selected subjects for operating coconut dehuskers:

The physiological parameters of selected male subjects are evaluated in the Ergonomics laboratory of the college. The age of the workers was taken in the range of 24-42 years. Their mean and standard deviation of weight and height were measured for analysis. Their body surface areas were in the range of 1.66 to 1.88 sq.m. Their VO₂ max (maximum aerobic power) measured in the laboratory, observed to be 1.91 l/min. The heart rate and oxygen consumption rate was measured during the work were measured for further analysis. The energy consumed in operating the machine was calculated in kJ/min (1 litre O₂ = 20.83 kJ).

RESULTS AND DISCUSSION

The experiment was conducted with two numbers of operators using coconut at various moisture contents. One is to feed the coconut into the dehusker and another one is to assist him as and when required and to remove the rest of the husk from dehusked coconut according to the requirements. Interim rest was given to the operators looking into their comfortability. The economics of using various coconut dehuskers has also been studied to know the comparative cost of using the machines. The performance of the dehuskers has been mentioned in

| Table 1 : Testing of Sakhigopal variety of coconut | | | | | | | | |
|--|-------------------------|-------|-------|-------|-------|-------|-------|-------|
| Type of dehusker | Moisture content (% Wb) | | | | | | | |
| | 0-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-35 | 35-40 | 40-45 |
| No. of nuts dehusked/hour | | | | | | | | |
| Locally | 75 | 100 | 85 | 75 | 72 | 70 | 68 | 55 |
| Hand operated | 118 | 150 | 130 | 128 | 115 | 103 | 86 | 75 |
| Pedal operated | 122 | 180 | 151 | 145 | 138 | 112 | 94 | 87 |
| Motor | 288 | 330 | 282 | 276 | 204 | 192 | 180 | 156 |

Table 2 : Dehusking efficiency for Sakhigopal variety of coconut

| Sr. No. | Dehusker | Total wt. of husk present (g) | Total wt. of husk removed (g) | Dehusking efficiency (%) |
|---------|----------------|-------------------------------|-------------------------------|--------------------------|
| 1. | Locally | 525 | 225 | 48.57 |
| 2. | Hand operated | 550 | 460 | 83.63 |
| 3. | Pedal operated | 540 | 460 | 85.18 |
| 4. | Motor | 530 | 490 | 92.45 |

Table 3 : Comparison of cost analysis for using different dehuskers

| Sr. No. | Particulars | Power operated Cost; Rs. 10000/- Life; 10 years Annual use 1000h | Hand operated Cost; Rs. 500/- Life; 10 years Annual use; 300h | Pedal operated Cost; Rs.750/- Life; 10 years Annual use; 300h |
|---------|---|---|--|--|
| 1. | Fixed cost (Rs./hour) | | | |
| | Depreciation | 950.00 | 118.75 | 178.12 |
| | Interest | 630.00 | 31.5 | 47.25 |
| | Shelter | 52.50 | 2.62 | 3.93 |
| | Total fixed cost/year | 1632.50 | 152.87 | 229.3 |
| | Total fixed cost/hour | 1.63 | 0.50 | 0.76 |
| 2. | Variable cost (Rs./hour) | | | |
| | Repair and maintenance cost/hour | 0.50 | 0.08 | 0.12 |
| | Labour charges/hour (2 labourers @ Rs. 100/day/ person) | 25.00 | 25.00 | 25.00 |
| | Electricity charges/hour | 3.15 | - | - |
| | Total variable cost/hour | 28.65 | 25.08 | 25.12 |
| 3. | Total cost (fixed + variable)cost/hour | 28.28 | 25.58 | 25.88 |
| 4. | Cost of dehusking/coconut | 0.10 (for 300 nuts/h) | 0.20 (for 125nuts/h) | 0.15 (for 170nuts/h) |

Table 4 : Physiological parameters of selected subjects (subject-5 nos. of male)

| Sr. No. | Age, yr | Weight, kg | Height, cm | Body surface area, sq.m | Heart rate (at rest), bpm | VO ₂ (rest) | HR (max), bpm | VO ₂ (max), l/min |
|----------------|---------|------------|------------|-------------------------|---------------------------|------------------------|---------------|------------------------------|
| S ₁ | 24 | 62.3 | 175.3 | 1.81 | 76 | 0.24 | 196 | 2.083 |
| S ₂ | 29 | 53.6 | 155.6 | 1.58 | 73 | 0.21 | 191 | 1.936 |
| S ₃ | 31 | 62.3 | 176.9 | 1.84 | 68 | 0.23 | 181 | 1.906 |
| S ₄ | 37 | 54.7 | 165.8 | 1.66 | 76 | 0.19 | 183 | 1.862 |
| S ₅ | 42 | 58.2 | 176.4 | 1.78 | 69 | 0.23 | 178 | 1.809 |
| Mean | 32.6 | 52.22 | 170 | 1.73 | 72.4 | 0.22 | 185.8 | 1.91 |
| SD | 7.0 | 4.0 | 9.2 | 0.1 | 3.7 | 0.02 | 7.4 | 0.1 |
| S.E.± | 3.13 | 1.83 | 4.13 | 0.79 | 1.69 | 0.08 | 3.37 | 0.04 |

Table 1 and 2. The cost of use of different dehuskers is presented in Table 3. Similarly the ergonomical assessment of the male subjects in operating the dehuskers has been mentioned in Tables 3, 4, 5, 6 and 7.

In case of power operated coconut dehusker, the mean value of heart rate of selected workers at rest was observed to be 78.6 ± 3.78 bpm. The average value of working heart rate from 6th minute to 20th minute of continuous operation was observed to be 115.2 ± 2.28 bpm when dehusked with the help of power operated dehusker. The corresponding oxygen consumption rate (OCR) of selected subjects was recorded to be 0.62 ± 0.08 l/min while dehusking in standing position. Lower WHR

(working heart rate) and OCR recorded during dehusking with power operated dehusker may be due to standing position. The relative cost of workload during these operations was recorded to be 32.96 ± 5.60 % (% of oxygen consumption rate to the VO₂ max). The lower overall discomfort rate was also recorded to be 4.4±0.41 for the power operated dehusker.

Conclusion :

The following conclusions are made from the study:
 – The number of coconut dehusked per hour was highest in power operated coconut dehusker followed by pedal operated dehusker, hand operated dehusker and

Table 5 : Ergonomical evaluation of male subjects working with power operated dehusker

| Sr. No. | Heart rate(rest),bpm | Heart rate (working),bpm | OCR (l/min) | EER (kJ/min) | RCWL (% of volume) | ODR (Overall discomfort rate) |
|----------------|----------------------|--------------------------|-------------|--------------|--------------------|-------------------------------|
| S ₁ | 75 | 116 | 0.59 | 12.3 | 28.3 | 4 |
| S ₂ | 76 | 114 | 0.50 | 10.5 | 26.2 | 4.5 |
| S ₃ | 77 | 118 | 0.66 | 13.8 | 34.6 | 4 |
| S ₄ | 81 | 112 | 0.67 | 14 | 35.9 | 4.5 |
| S ₅ | 84 | 116 | 0.72 | 15 | 39.8 | 5 |
| Mean | 78.6 | 115.2 | 0.62 | 13.12 | 32.96 | 4.4 |
| SD | 3.78 | 2.28 | 0.08 | 1.55 | 5.60 | 0.41 |
| S.E.± | 1.69 | 1.01 | 0.27 | 0.69 | 2.50 | 0.18 |

Table 6 : Ergonomical evaluation of male subject working with Hand Operated dehusker

| Sr. No. | Heart rate(rest), bpm | Heart rate (working),bpm | OCR (l/min) | EER (kJ/min) | RCWL (% of volume) | ODR (Overall discomfort rate) |
|----------------|-----------------------|--------------------------|-------------|--------------|--------------------|-------------------------------|
| S ₁ | 75 | 125 | 0.72 | 15 | 34.6 | 5 |
| S ₂ | 78 | 124 | 0.69 | 14.9 | 36.2 | 4.5 |
| S ₃ | 80 | 122 | 0.70 | 14.6 | 36.7 | 5 |
| S ₄ | 73 | 118 | 0.76 | 15.9 | 40.8 | 5.5 |
| S ₅ | 82 | 126 | 0.79 | 16.5 | 43.4 | 5.5 |
| Mean | 77.6 | 123 | 0.73 | 15.38 | 38.34 | 5.1 |
| SD | 3.64 | 3.16 | 0.04 | 0.79 | 3.63 | 0.41 |
| S.E.± | 1.62 | 1.41 | 0.01 | 0.35 | 1.62 | 0.18 |

Table 7 : Ergonomical evaluation of male subject working with Pedal Operated dehusker

| Sr. No. | Heart rate(rest), bpm | Heart rate (working),bpm | OCR (l/min) | EER (kJ/min) | RCWL (% of volume) | ODR (Overall discomfort rate) |
|----------------|-----------------------|--------------------------|-------------|--------------|--------------------|-------------------------------|
| S ₁ | 76 | 122 | 0.72 | 14.8 | 34.6 | 4.5 |
| S ₂ | 80 | 124 | 0.68 | 14.2 | 35.1 | 5 |
| S ₃ | 80 | 119 | 0.62 | 12.9 | 32.5 | 5 |
| S ₄ | 82 | 118 | 0.60 | 12.6 | 32.3 | 4.5 |
| S ₅ | 84 | 123 | 0.69 | 14.4 | 38.1 | 5 |
| Mean | 80.4 | 121.2 | 0.66 | 13.78 | 34.52 | 4.8 |
| SD | 2.96 | 2.58 | 0.05 | 0.97 | 2.35 | 0.27 |
| S.E.± | 1.32 | 1.15 | 0.02 | 0.43 | 1.05 | 0.12 |

local method of dehusking.

– The number of coconut dehusked per hour in power operated coconut dehusker was almost double than that of pedal operated dehusker.

– The dehusking efficiency was observed to be highest in power operated coconut dehusker followed by pedal operated dehusker, hand operated dehusker and local method of dehusking.

– The cost of use of the power operated dehusker was also nominal i.e. Rs. 0.10 per nut followed by Rs. 0.15 for pedal operated dehusker and Rs. 0.20 for hand operated dehusker.

– The operator developed lower working heart rate

(115.2 ± 2.28), lower oxygen consumption rate (0.62 ± 0.08 l/min), lower relative cost of work load (VO₂ max = 32.96 ± 5.60%) and lower over all discomfort rate (4.4 ± 0.41) in power operated dehusker compared to other hand operated and pedal operated dehuskers which indicated the comfortable use of the power operated one.

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