Development of an animal-powered rice-huller

K. Dippon*

Abstract

The mechanization of agriculture in developing countries is necessary to guarantee a sufficient nutrition for the future. The use of animal power is an important stage in realising the social and economic conditions for introducing and continuing mechanization. Based on the results of research on rice-hullers at Hohenheim University a new rice-huller was developed, adapted to an animal-powered gear and installed and tested in Niger. The hulling-system has a capacity up to 200 kg paddy/h and draught force requirements between 200 and 250 N. Also handling is very easy because no adjustments are necessary to operate the huller.

Objectives

For most of the rural population, animal-powered gears are the only practicable alternative to manual labour for work such as water-lifting, sugar cane crushing, grinding of cereals and dehusking of rice (Boie 1989).

In many African countries dishes made of flour are the staple. Processing of the cereals is carried out, normally by women, in the traditional labour- and time-intensive way, using wooden mortars or grinding stones. Within the GTZ/GATE project 'Documentation, improvement and dissemination of animal-powered technology' research and development was carried out at Hohenheim University to identify and adapt a rice-huller to the animal- powered gear. The system was then installed at ARDETEC station in N'Dounga, Niger.

Identification and adoption of the most suitable rice-huller

Working on different principles, three small rice hullers were purchased,two of them run according to the American System (Huysmans 1971). This system is centred around the utilization of the **Engelberg-huller** (Kishan-huller). With this machine, hulling and polishing (removal of different layers below the husk) can be done in several stages during the same passage. Engelberg-hullers are widely used in small mills for milling rice for local markets.

*Institute for Agricultural Engineering, Hohenheim University, Stuttgart, F.R. Germany

The essential principle of the Engelberg-huller is that of a roller revolving inside a casing (Fig. 1). Normally, four ribs are located round the surface of the roller. When paddy is fed into the machine the revolving roller propels the paddy along the cylinder between the ribs. A fixed adjustable blade prevents the rice swirling round within the cylinder while the paddy is hulled between the ribs of the roller and the blade. The main disadvantages of Engelberg-hullers are the high power requirements at a low-level capacity and, as illustrated in Table 1, the high losses of essential components of the grain. Furthermore, the process of polishing reduces the content of vitamin B1 by about 75% (Leonhard and Martin 1963) compared with brown rice (natural coloured

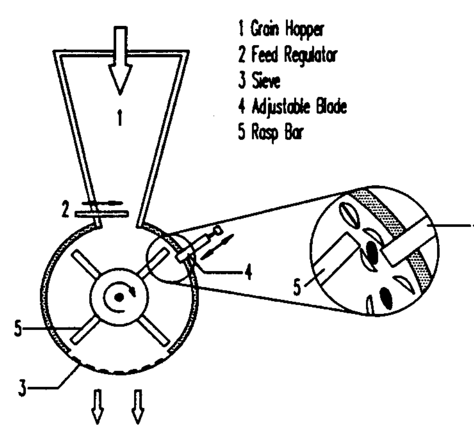

Fig 1. Engelberg-huller

Table 1. **Component of paddy, hulled and polished rice (in % dry basis)**

Component	Paddy rice	Hulled rice	Polished rice	Losses during polishing (%)
Protein	7.1	8.6	8.1	5.8
Fat	2.4	2.6	0.5	80.7
Carbohydrates	77.8	86.3	90.4	-4.4
Crude fibre	8.6	1.0	0.4	60.0
Ash	4.1	1.5	0.6	60.0

Source: Salunkhe et al. 1985.

rice). When the diet consists too exclusively of polished rice, the deficiency disease beri-beri becomes prevalent.

The hulling-principle of the third huller is based on centrifugal-force and is therefore called the Centrifugal-huller. The machine consists essentially of the accelerating disc, the drive unit and the huller-drum. To achieve optimum hulling-efficiency, the disc must rotate at a speed in the range of 3000 to 4000 rpm. By opening the feeder-gate, paddy is fed into the center of the rotating disc. The impact caused by the rotating catchers of the disc is sufficient to crack the husks when they crush against the huller-drum (Fig. 2). To avoid brockens, the drum is made conical and covered with a rubber cushion in the hulling area. The high kinetic energy and air flow causes the husks, together with the brown rice, to be expelled at the bottom of the drum. Compared with the Engelberg-hullers, this machine requires much less power at a high-level capacity and also reduces brockens.

The Engelberg-huller needs four times more power at the same output level than the Centrifugal-huller (Fig. 3). The various openings specify different cross-sections of the feeder-gate opening.

As a result of research on the three hullers, the centrifugal-huller was chosen for adaptation to the animal-powered gear. This included the construction of a two stage gear box.

The animal-powered rice-huller

This section gives a short description of the different parts of the hulling-system; refer to Fig. 4 for a general view of all parts described below.

1. The path

   The main function of the path is to ensure good power-transmission between the car wheel and the ground. It consists of two rows of concrete blocks and is covered by a

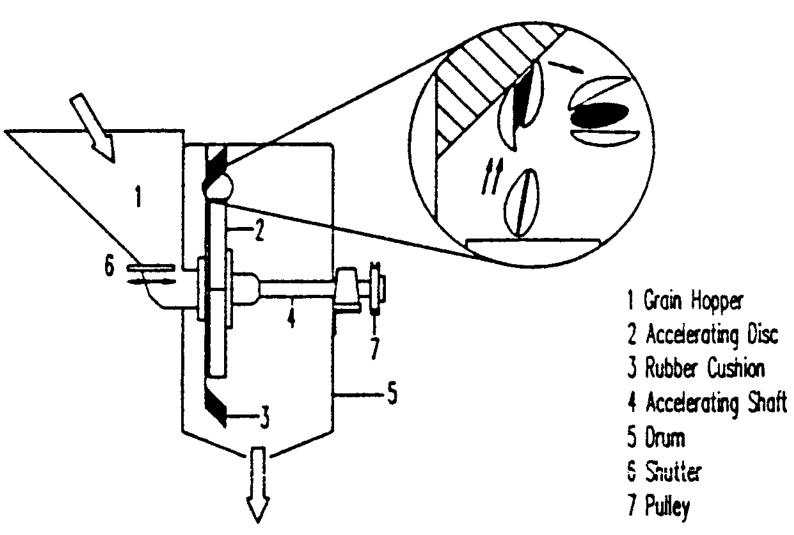

Fig 2. Centrifugal-huller

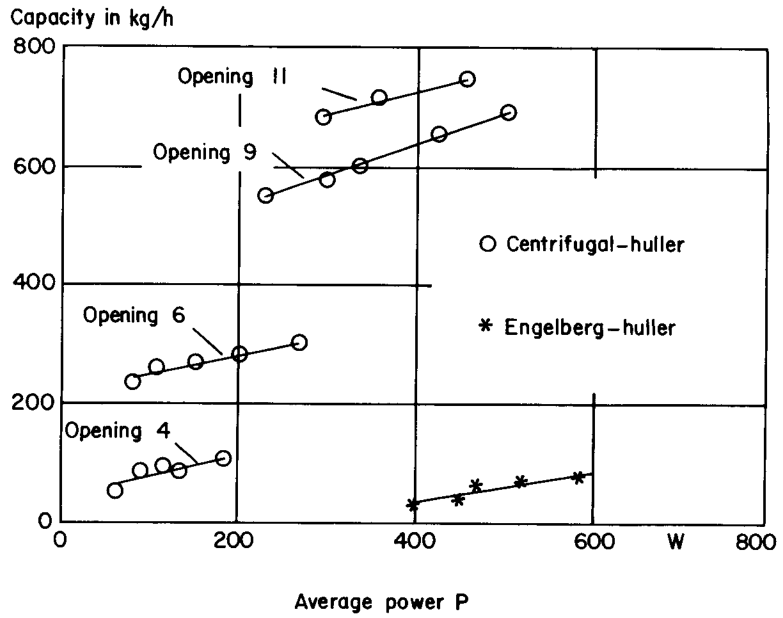

Fig 3. Capacity of Engelberg- and Centrifugal-huller

more solid concrete layer to reinforce the construction. This corresponds to a height of 40 to 50 cm. To reduce abrasion, the covering is fortified with reinforcing iron. For good working performance the path has to be as round and level as possible.

2. The frame and harnessing

These parts of the hulling-system are made of round pipes (60 x 3 mm, 48 x 3 mm) and fulfil the following functions:

1. The fastening of the rice-huller with the gear box and the drive unit
2. Carrying the seat of the user
3. Connecting the drive unit with the central axle to enable the circular movement of the wheel
4. The transmission of the tractive power of the animal to the power gear

With regard to the harnessing, it is very important to keep tractive losses to a minimum. This requires a horizontal and tangential power-transmission.

3. The drive unit

This unit is necessary to transform the draught force of the animal into a rotary motion and to increase the speed of rotation. It is realised with two wheels of different size. The first one, which runs along the path is a normal car wheel of the size 155 R 13. The second one (friction wheel), powered by the car wheel, has a diameter of 12 cm and is made of steel. The maximum power which can be transmitted by the drive unit in the first gear stage (path-car wheel) is limited to:

$$P_{1max} = \mu_1 \times F_g \times r \times 2\pi \times n/60 \times \eta_1 \qquad ())1$$

μ_1 = coefficient of friction (path - car wheel)

F_g = weight [N]

r = radius of the car wheel [m]

n = speed of the car wheel [min^{-1}]

η_1 = efficiency of the power transmission (path - car wheel)

For the second gear stage (car wheel-friction wheel) the limiting value can be calculated as:

$$P_{2max} = \mu_2 \times F_p \times r \times 2\pi \times n/60 \times \eta_2 \qquad ()1$$

μ_2 = coefficient of friction (path - car wheel)

F_p = weight [N]

r = radius of the car wheel [m]

n = speed of the car wheel [min^{-1}]

η_2 = efficiency of the power transmission (path - car wheel)

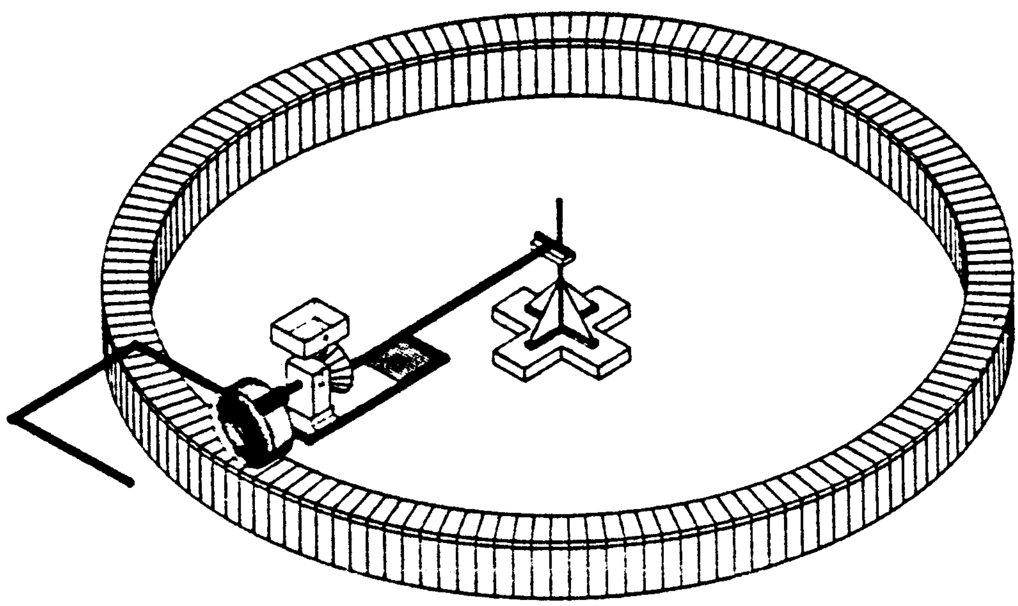

Fig 4. Animal-powered rice huller

The losses occurring in the two stages of transmission are mainly caused by bearing friction and rolling resistance.

4. The central axle

The central axle is very important for the precise running of the wheel on the path. Therefore it must be located exactly in the centre of the path and absolutely vertical.

5. The gear box

To achieve the speed of rotations required for good hulling efficiency, a two stage gear box is mounted between the huller and the friction wheel. The gear box consists of two identical pairs of toothed wheels with a gear-ratio of 1: 31.2. To avoid damaging the bearings, closed standard bearings are used. The power-transmission between the car wheel and the gear box is achieved by a small friction wheel (d = 12 cm) screwed on to the input shaft extension of the gear box and pressed to the surface of the car wheel tyre. To get sufficient pressure, the gear box together with the huller is mounted rotary to the frame on one side. A threaded rod welded to the frame on the other side allows the adjustment of pressure. The gear-ratio of the friction wheel transmission is 1:5. For safety, the friction wheel is covered by thin sheet-metal.

6. The huller

The centrifugal-huller is screwed onto the gear box together with the feed hopper, which has a capacity of 10 kg of paddy. To start hulling, the operator opens the feeder gate allowing the paddy to be fed into the centre of the accelerating disc. The disc is closed on both sides (with the exception of the point where the paddy is fed) 2 cm wide and equipped with four catchers. The huller-drum and the removable cover are made of sheet-metal. In the area where the paddy crushes against the drum, a rubber sheet is mounted. The hulled paddy and the husks leave the huller in a 2 in pipe welded to the cover. To catch the material, a simple rack is mounted to the frame.

Installation

Materials and methods

The hulling-system built at Hohenheim University, was installed and tested during Feb – Mar 1990 at the ARDETEC station in N' Dounga, Niger. Various tests were carried out to analyse the working performance of the unit, measuring the following parameters:

1. Torque M_d
2. Speed of rotation n
3. Traction force F

The data were recorded continuously during the tests using a data-recorder and afterwards evaluated by computer.

Most of the tests were carried out using a donkey (liveweight 150 kg) and local rice with a moisture content of 7.5 %.

Results

The next figure shows the torque measured between the friction wheel and gear box. When the donkey starts walking, the torque does not exceed 30 Nm because of the friction wheel transmission, which acts like a friction clutch. By changing the pressure between the wheels, the limiting value can be adjusted to different conditions. Furthermore the friction-clutch prevents injury to the donkey. During hulling the maximum torque is 30 Nm; it is negative when the donkey stops.

The power required for driving the hulling-system can be realised by one donkey without problems. As Fig. 6 illustrates, the draught force reaches its maximum value of 310 N when the donkey starts. During the period of hulling, the mean value is 220 N. At the same time, the accelerating disc rotates in the range of 3300 up to 4000 rpm.

The efficiency η_{du} ($\eta_1 \times \eta_2$)of the drive unit can be calculated by dividing the power P_g measured at the axle between gear box and friction wheel and the power P_a of the draught animal:

$$\eta_{du} = P_g/P_a \qquad (3)$$

The investigations have shown, that the efficiency η_{du} of the drive unit is in the range of 84 – 86%. Yet one has to take into account that the surface of the path and the wheels, the pressure of the tyre, the pressure between the wheels etc. can decrease the efficiency to a considerable extent. Driven by a donkey, the capacity of the huller is between 250 and 300 kg of paddy/h. With one passage it is possible to dehusk about 90-95% of the rice. After a second passage the rice is completely dehusked. Because the second passage increases the capacity up to 400 kg/h, dehulling with two passages translates to a total capacity of 150 to 200 kg paddy/h. As illustrated in Fig.7, the traditional method of rice-hulling produces 15 to 20 kg paddy/h

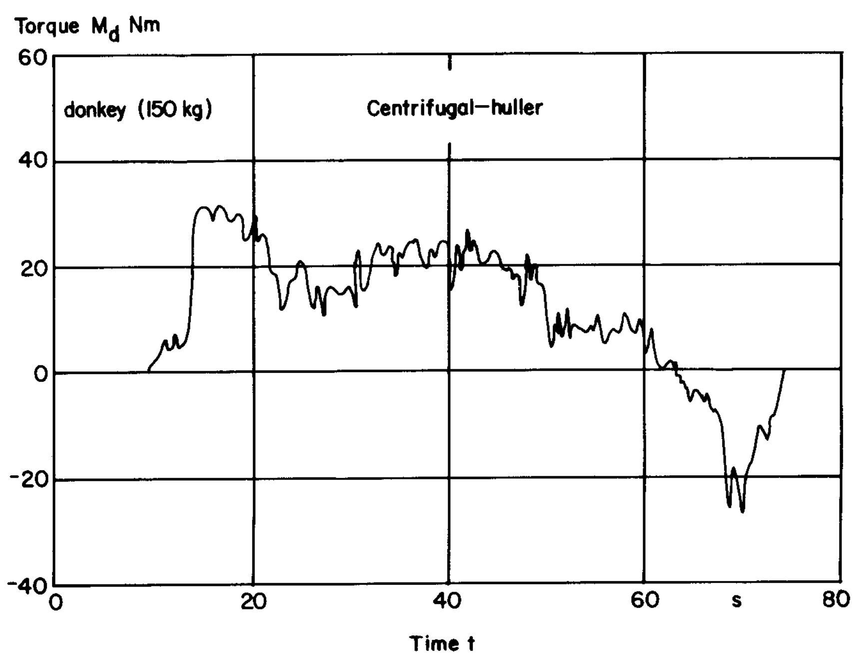

Fig 5. Torque during hulling

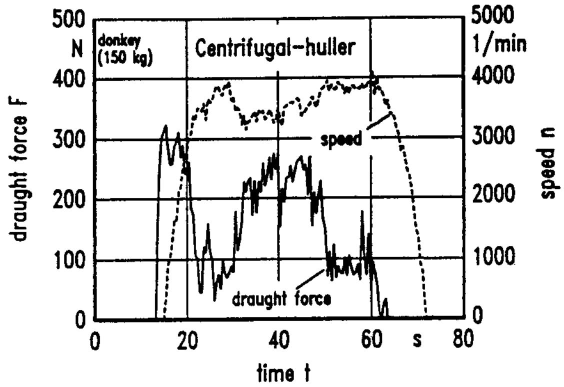

Fig 6. Draught force and speed of the hulling-system

(Leonhard and Martin 1963)-about 15 times less than the animal-powered rice-huller.

Conclusion and discussion

As the investigations and field-tests have shown, the centrifugal-huller driven by a donkey is able to reduce considerably the time necessary for dehusking rice. At the same time the exacting work of traditional hulling is reduced for the women.

To operate the hulling-system no adjustments are required and its ease of handling allows anyone to use it without special training.

The simple construction of the attachment of the huller to the drive unit makes it possible to exchange the huller with a cereal-mill in a short time.

Acknowledgements

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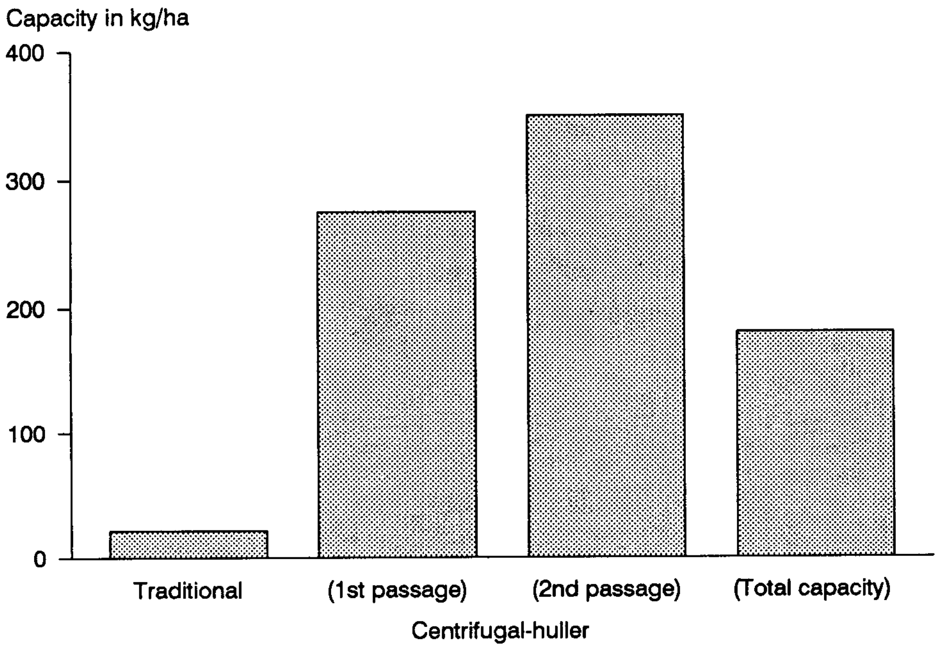

Fig 7. Capacity of Traditional and animal powered rice-hulling

Résumé

La couverture des besoins alimentaires des pays en développement passe par la mécanisation de leur agriculture. L'utilisation de la traction animale constitue une étape importante dans l'instauration de conditions économiques et sociales favorables à l'introduction et au maintien de la mécanisation. A la lumière des résultats d'études effectuées à l'université de Hohenheim sur le décortiqueur, un nouvel appareil a été mis au point et installé et testé au Niger. Entraîné par traction animale, ce nouveau système de décorticage a une capacité de 200 kg de paddy à l'heure et requiert une force de traction de 200 à 250 N. Il est très facile à manier, son fonctionnement ne nécessitant aucun réglage.

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