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Development and Evaluation of Modified Rubber Roll Dehusker for Enhanced Husking Efficiency of Paddy

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ABSTRACT

A laboratory experiment was conducted to study the affect of different roll angles on the husking efficiency of a rubber roll dehusker with a view to increase the husking ratio of the machine. The existing horizontal roller arrangement was modified to an oblique roller arrangement and a modified feed flow plate was incorporated in the dehusker. Provision was made for the main roller to adjust its position with an angular displacement. Paddy variety PR-114 with moisture content of 14±0.5 percent on wet basis was selected for the study. The performance evaluation of the dehusker at different roll angles was studied. The optimum feed rate was determined and the optimum roll angle was also estimated. A comparison was made between the present existing roller arrangement and the modified oblique roller arrangement. Data was statistically analyzed to know the significant affect of the two parameters studied viz. feed rate and roll angle on husking ratio. The modified roller arrangement along with a feed flow plate significantly increased the husking ratio of the dehusker. The husking ratio was maximum (88.31%) at a roll angle of 40° when the feed rate was 25 kg/hr in the modified husker whereas the husking ratio was only 85.13% in the horizontal roller arrangement at the same feed rate.

Key words : Dehusker, Feed flow plate, Husking ratio, Paddy, Roll angle,Oblique roller arrangement.

World production of rice is estimated around 685 million tons, equivalent to that of wheat (FAOSTAT, 2010). Rice alone constitutes 42% of the total food grains produced in India (Krishnaiah and Janaiah, 2000). Rice is of great antiquity and is closely bound with the life and dietary habits of a vast number of people in India. Rice milling is a gigantic industry in India. According to make and design, different machines have different methods of dehusking *viz*. husking by action of shear and compression, impact, abrasion and friction. There are machines like *Engel berg* rice huller, impeller type rice dehusker, under runner disc sheller and rubber roll dehusker which perform the husking at different levels.

In the process of dehusking, the action of tension, compression and friction are applied to paddy. Due to the non-homogenous structure of paddy, the kernel breaks during milling which cannot be avoided, but efforts were made to minimize this broken percentage.

Since the introduction of *Engel berg* huller, different huskers were tried to reduce the breakage of rice to minimum during milling, as the main problem that beset the rice industry is the degree of kernel damage. In general, the volume of broken kernels range from 15.82 to 72.76% with an average of 40.19% of the total milled rice for the rubber roll type rice mills (Anonymous, 1985) Essentially, this results in great loss because it lowers the market value of the product. The ultimate goal of rice industry is to achieve maximum total and head rice yields from the milling process and keep the loss in quality and quantity to minimum.

The important utility in rice processing plant is electricity. About 58.68kW electric power is consumed to handle 3 tones of paddy in one hour (Bakhara *et al,* 1991). By improving the husking ratio of dehusker, the electric power can also be saved. In the present study, an attempt has been made to design, develop a rubber roll dehusker by changing the position of one of the rolls and modifying the feeding mechanism.

THEORETICAL CONSIDERATIONS

Literature reviewed showed that the main draw back of the present rubber roll dehusker is the less head rice recovery. A machine therefore

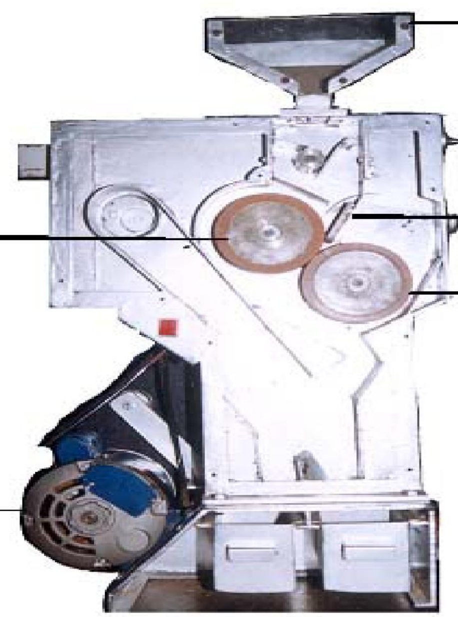

Figure. 1. Modified rubber roll dehusker

needs to be developed and evaluated for its improved husking efficiency. When two rubber rolls are obliquely arranged, they make the longitudinal supply of rough rice easy (Anonymous, 1995). Based on this fact, the roller arrangement was modified into an oblique position. Provision was made for the fast roller, so that it can be moved vertically.

MATERIAL AND METHODS

The design and fabrication of a mini paddy dehusker was done in the department of Processing and Agricultural Structures, College of Agricultural Engineering, Punjab Agricultural University, Ludhiana. The laboratory experiment was conducted during the year 2002. The dehusker consisted of two rubber rolls rotating in opposite direction inwards (Figure.1). The slow moving rubber roll was adjustable laterally in order to increase or decrease the clearance between the two rolls. Provision was made for the fast roller, so that it can be moved vertically. The technical specifications of the dehusker are given in Table.1.

Paddy

The variety PR-114, recommended by Punjab Agricultural University to be grown in Punjab was selected for testing. It has long slender grains. The paddy was cleaned and dried to about 14% moisture content (wet basis).

Roll angle

Roll angle (α) is defined as the angle between the line joining the centers of the rolls when the rolls are in horizontal position and the line joining the centers of rolls when one of the rolls was moved vertically (Figure 3).

Operation and collection of data

The dehusker was operated at the designed speed specified for both the rolls. The test was conducted for half an hour at the rated capacity (25kg/hr). During the above run, six samples of shelled rice from rice outlet were collected at an interval of 5 minutes. At the end of half an hour feeding, the dehusker was run idle for some time. The same procedure was carried out at three different feed rates, viz.20, 25and 30kg/hr.

Table.1.Technical specifications of the modified dehusker.

Particulars	Specification
Rubber rolls	
Size	13.0cm
Face width	4.0cm
Main roller speed	1266rpm
Auxiliary roller speed	900rpm
Hopper	
Height	16.0cm
Feed mouth	24.0x12.0cm^2
Opening	3.0x3.0cm^2
Power transmission	
V-belt designation	A-type
Belt length adopted	64inch
Belt cross section	13.0mmx8.0mmx7.0mm
Weight per meter belt	0.106kgf
Main roller pulley size	8.5 cm
Auxiliary roller pulley size	12.0cm
Fan pulley size	4.5 cm
Fan	
Type	centrifugal and backward curved
Size	15.0cm
Number of blades	8
Blade angle	48°
Speed	2500 rpm
Electrical system	The motor selected for the dehusker had the following specifications:¼ hp, 1425 rpm, 220/230V single phase, 50Hz, 2.6A

All the above tests were conducted keeping the rollers in horizontal position (Figure 2). The tests were conducted at different roll angles by lowering the fast rotating roller (Figure 3). The different roll angles chosen were 10^0, 20^0, 30^0, 35^0, 40^0, 45^0 and 50^0. All the observations were taken at different roll angles using the modified feed arrangement. The roll angle was measured with the help of a bevel protractor and the gap between rolls was checked with a filler gauge.

Feed flow plate

In the modified dehusker, a feed flow plate is designed with v-shape channels, which directed the grain flow in longitudinal.

Preparation and analysis of samples

The six sets of samples obtained for various feed rates were thoroughly mixed separately to form a composite sample for each feed rate. Out of each composite sample, 100gm of sample was taken and analyzed manually for the presence of unshelled paddy.

Calculation of husking ratio

From the observations made above, the results were calculated and have been expressed in terms of husking ratio, which is defined as follows:

$$A=\frac{B}{(B+CD)}$$

Where,
A=husking ratio (%)
B=weight of brown rice collected at the outlet (gm)
C=weight of unshelled paddy collected at the outlet (gm)
D=percentage of mass of brown rice when the paddy sample was manually husked=0.78

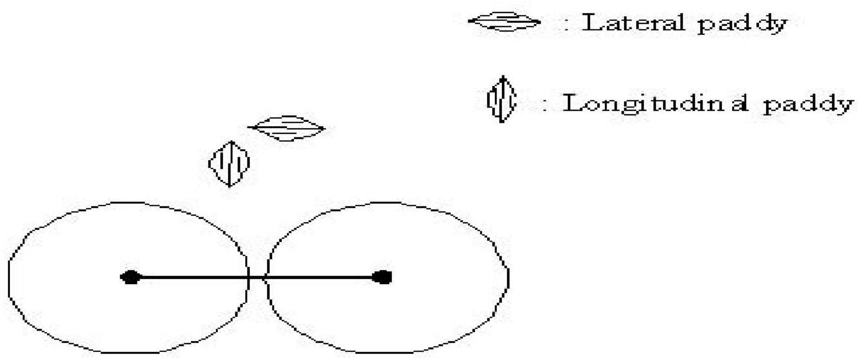

Figure 2. Horizontal roller arrangement (Both longitudinal and lateral supply of paddy grains)

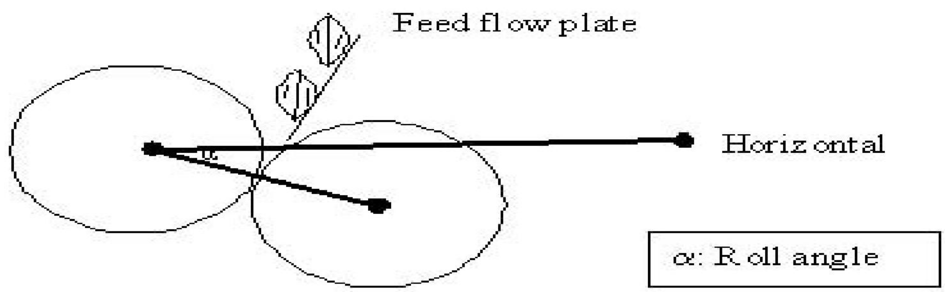

Figure 3. Oblique roller arrangement (Only longitudinal supply of paddy grains to a larger extent)

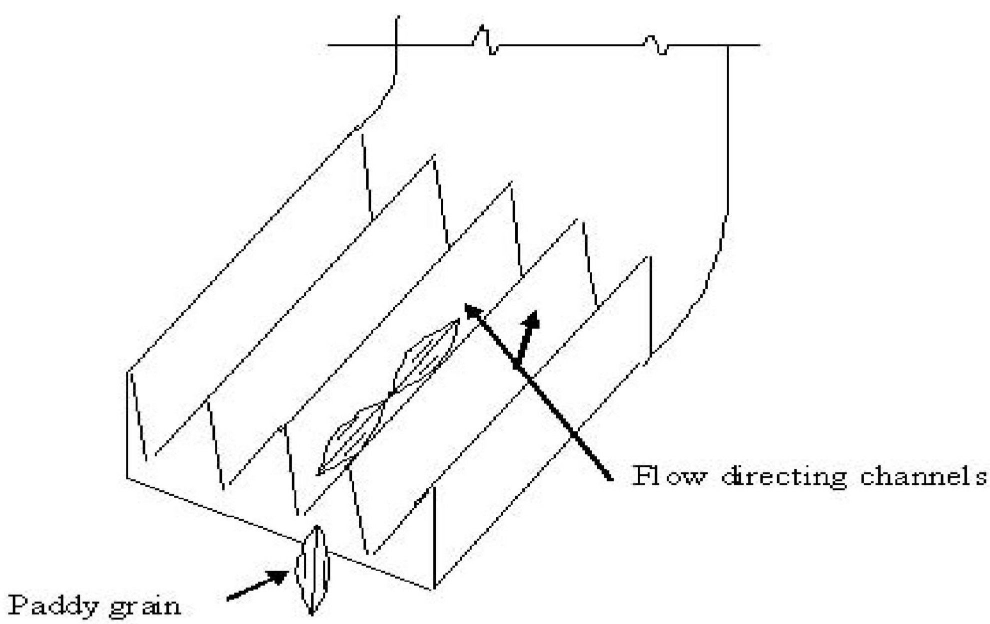

Figure 4. Schematic diagram of feed flow

Statistical analysis

The data was statistically analyzed by using *CPCS1* computer software package (Cheema and Singh, 1990). Completely randomized design in factorial technique was employed to calculate the critical difference (CD) at 5% level of significance and coefficient of variation (CV).

RESULTS AND DISCUSSION

Performance evaluation

Performance of machine was assessed by plotting curves for husking ratio against roll angle and feed rate separately. The results reported are in two parts. The first part deals with the performance of the dehusker at different angle between rolls with a view to determine the best roll angle. The second part describes the performance of machine at various feed rates to select the optimum feed rate.

Effect of roll angle on husking ratio

It was evident that the husking ratio increased with roll angle (Table.3). There is an increase in the husking ratio with the roll angle for all the three feed rates. The maximum husking ratios obtained were 88.35, 88.31 and 87.67 per cent at the roll angles of 35°, 40°and 45° respectively for the corresponding feed rates of 20,25 and 30kg/hr.

So, the optimum roll angle selected was 40°. As the roll angle is increased further beyond 45(or50°) the husking ratio decreased drastically. This may be because of the fact that, at roll angles beyond 45º, the paddy flow under the influence of gravity could be impaired. Also the longitudinal and tangential pattern of paddy is disturbed beyond 45°.The increase in husking ratio with the roll angle may be attributed to the oblique arrangement of the rolls. The modified arrangement resulted in the longitudinal supply of rough rice easy. Thus the husking ratio differs according to the direction of rice grains supplied to the rubber roll. Rice grains aligned longitudinally increased the husking ratio. This increase in husking ratio is considered to be affected by longer contact length and higher coefficient of friction with longitudinally supplied rice grains. Therefore, the shearing stress required for dehusking had been considered to be smaller for the longitudinally supplied rice grains (Anonymous, 1995). The analysis of variance showed that changing the position of main roller significantly affected the husking ratio.

Effect of feed rate on husking ratio

From the experimental data, it was observed that there was a gradual increase in husking ratio with feed rate up to a certain level and started decreasing. The husking ratio increased when the feed rate was increased from 20 to 25 kg/hr and then decreased when the feed rate was increased to 30 kg/hr. Though the maximum husking ratio was observed at a feed rate of 20 kg/hr (88.35), the husking ratio of 88.31 per cent at a feed rate of 25 kg/hr was considered the optimum. This is so, because of the reason that a significant increase in feed rate by 5kg/hr resulted in an insignificant decrease (0.045per cent) of husking ratio.

The increased values of unhusked percentage at higher feed rates may be due to the development of insufficient shear force for peeling off the husk, resulting from lower values of contact pressure. Thus the oblique arrangement of rolls gave an increase of 3.73 per cent in the husking ratio at the optimum feed rate of 25kg/hr, as compared to the conventional roller arrangement. The analysis

Table 2. ANOVA for husking ratio. (Number of replications-3, Number of factors-2, A-Roll angle, B-Feed rate).

Source	d.f	M.S	F-Ratio	CD (5%)	C.V
A	7	59.364090	37.82	1.18710	
B	2	25.864580	16.48	0.726948	
AB	14	2.2881940	1.46	NS	
Error	48	1.5696610			1.48

Table 3. Effect of roll angle and feed rate on mean husking ratio.

S.No.	Roll angle (In degrees)	Husking ratio (%) Feed rate (kg/hr)		
		20	25	30
1	0	81.79	85.13	81.54
2	10	81.07	84.86	82.43
3	20	84.94	85.04	83.39
4	30	86.71	87.57	85.33
5	35	87.24	86.96	84.95
6	40	88.34	88.31	86.14
7	45	87.82	88.26	87.67
8	50	80.20	81.93	80.09

of variance for husking ratios showed that the husking ratio varied with the roll angle as well as feed rate significantly. From the statistical analysis of data (Table 2.), it can be concluded that the best-suited roll angle is 40° at an optimum feed rate of 25k/hr.

The modified arrangement will result in lower wear and tear of rubber rolls, ensuring a longer rubber roll life. This point is obvious from the fact that the longitudinal position of paddy needs less shear force for husking compared to the lateral position of the grain, thereby ensuring less rubbing action over the roller.

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