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Design and Development of Maize Sheller

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Abstract: ***Maize is one of the main grain crops in the world agriculture economy. The grains are removed by workers holding the cob in one hand and using pressure of the other hand. This traditional method is laborious, time consuming, low output and costly. A lowcost maize sheller has been developed in this project to overcome the difficulties of traditional method. This manually operated rotary maize sheller is of low cost and the output is 5kg/hr as compared to the traditional method. This equipment would be useful for farm worker and increase their efficiency and earning. The detachment of grains from cob has been found to be maximum at grain moisture of 12%. The recovery heart rate and resting heart rate of the workers have been found to be almost same.***
Keywords: Maize, maize sheller, shelling, small farmers.

I. INTRODUCTION

Maize is one of the most important cereal crops cultivated in this world after wheat and rice. The annual production of maize in the world is 856 million tons as compared to 24.51 million tons in India (2016-17). It has exceptionally high yield potential and is normally known as "Queen of grains". The largest maize producing state of our country is Andhra Pradesh with an annual production of 17.84 lakh tonnes. In Odisha, maize is grown in districts of Boudh, Gajapati, Kalahandi, Ganjam, Koraput, Malkangiri and Rayagada. The annual production of maize in Odisha is 7.51 lakh metric tons covering an area of 2.69 lakh ha with an average productivity of 2791 kg/ha (2019). The highest maize producing district is Nabrangpur with an estimation of 124 lakh quintal covering an area of 40.67 Kha with an average productivity of 3064 kg/ha.

Shelling operation is the most important postharvest operation for grains, nuts and other oil crops after harvesting, and can be done manually or mechanically.

Shelling is the method which involved with process of removing seed/grain/kernels from their cobs for both human and industrial use. The trouble of the cycle relies upon the varieties grown, moisture content, and development of the grain. Different methods of shelling can be categorized based on mechanization technology.

For the ergonomic evaluation of a farmer which is impacted by the well-being of operators, nutrition, basal metabolic rate, and energy used while working. Heart rate is a better index of the overall physiological demand of work than energy expenditure, and is easier to measure in the field. It is used to assess physiological workload.

II. MATERIALS AND METHODS

This part portrays about the plan and creation of hand worked maize sheller and its exhibition assessment examination with manual maize shelling.

The analyses were directed at Gandhi Organization for Technology, Odisha during the period of 2022-2023 to evaluate the ergonomic and performance evaluation.

The techniques for planning the maize sheller is finished in three stages, the assortment of rural farmers sheller needs connected with horticultural activity, the plan of a suitable shelling framework to address their issues and to decide if their problem can be tackled.

A. Maize Sheller

A maize sheller is a hand-operated gadget or a part of machinery to shell maize parts off the cob for feeding farm animals or for different purposes. The hand operated maize sheller consists of mainly Frame, Octagonal Rotatable Hollow Cylinder and Handle.

1) *Frame:* It is made up of iron, the sheller unit is fixed to the frame work.
2) *Octagonal Rotatable Hollow Cylinder:* It rotates when the handle is rotated, made up of iron with edges inside to produce the shearing force.
3) *Handle:* It is connected to the hollow cylinder by a rod via the main frame

Fig. 1 maize sheller

Fig.2 Rotatable octagonal hollow cylinder

Fig.3 Frame

Fig.4 Handle

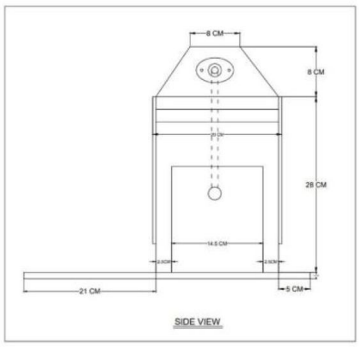

Fig. 5 AutoCAD Side view

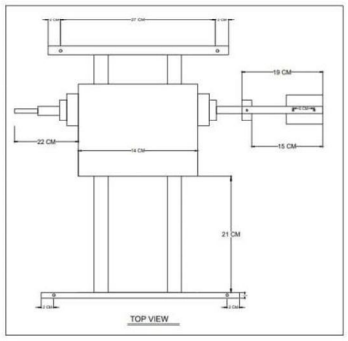

Fig. 6 AutoCAD Top view

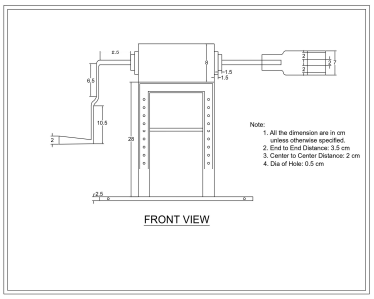

Fig. 7 AutoCAD Front view

B. Working of the Maize Sheller

The maize sheller is made of iron frame with support legs or stands which can be kept on table tops or elevated platforms. The middle frame holds the handle which is connected by a rod to a hollow cylinder with edges inside. In operation the maize is inserted more than half way into the hollow cylinder, then the handle is rotated. The maize is shelled by the shearing force between the edges and the maize grains when the handle attached to the cylinder is rotated. The grains fall under the cylinder after being shelled from the cob.

First, the maize cob is dried under the sun to get the required moisture content for maize shelling.

The pivot of the chamber creates a shearing force which removes grains from maize cobs and parts which were gathered at the base. One person was engaged for these operations, one hand inserting maize cobs at the mouth of the cylinder and the other rotating the handle. The kernels fall to the bottom after being shelled.

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C. Performance Evaluation

A local maize variant was collected and sun-dried for 2–3 weeks.

We started the shelling operation to get the kernels and access the units while working.

The kernels are then kept in a moisture content box, each filled with 5-10gms (for both the 5 maize and 12 maize experiments), and weighed. We then dried the maize in a hot air oven for 24 hours at 97°C. After 24 hours, we weighed the moisture content box with the kernels. Then the moisture content was calculated to find the suitable moisture content range for the local variety of maize that can be used for this machine. The result of observation with 5 cobs are given below in I and II

TABLE I PHYSICAL PROPERTIES OF MAIZE COBS

Serial No. of maize	Length (in cm)	Top width (in cm)	Thickness (in cm)	Bottom width (in cm)	Weight (in g)
1	14.5	3.5	14	3.7	130.62
2	19.5	4	15.4	3.7	153.32
3	14	4.5	11.6	3.8	118.10
4	18.3	4.5	6.4	3.9	192.00
5	16	4.7	15.4	4.2	178.13

TABLE II MOISTURE CONTENT

Serial No. of maize	W1(empty moisture box)	W2(moisture box + 5 gm of maize cob)	W3(after for 24 hours weight of moisture with 5 gms of maize cob)	Moisture content in percentage
1	31.24	36.24	35.35	17.8
2	28.20	33.20	32.37	16.6
3	28.71	33.71	32.83	17.6
4	28.93	33.93	33.06	17.4
5	28.01	33.01	32.13	17.6

TABLE III KERNEL LOSSES

Serial no. of maize	Before Shelling corn kernel	After Shelling	Losses
1	650	433	217
2	755	415	340
3	430	380	50
4	790	459	331
5	714	410	304

This experiment was conducted by using one female worker and one male worker

The result of observation with 10 maize's are given in Table IV and V

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TABLE IV PHYSICAL PROPERTIES

Serial no. of maize	Length (in cm)	Top width (in cm)	Thickness (in cm)	Bottom width (in cm)	Weight (in g)	Time (in sec)
1	17	3.5	13.7	1.7	185.34	51.34
2	15.5	3.7	13.5	2	138.38	57.21
3	14.5	3.5	14.3	2.2	129.02	45.71
4	17	4	13	2.2	184.56	31.13
5	16	3.6	15	2	177.49	46.23
6	16.5	3.7	13.7	3	178.40	34.33
7	15.5	4	15.5	2.7	173.25	36.44
8	14.9	4	14.5	2.5	134	30.14
9	15.8	4.2	14	3.8	179.98	51.25
10	14.5	4.1	13.8	3.5	129.08	34.33
11 (manual)	15.5	4.3	14.2	3.6	171.32	120.10
12 (manual)	15.3	4.3	14	3.6	176.45	158.86

TABLE V MOISTURE CONTENT

Serial No. of maize	W1(empty moisture box)	W2(moisture box + 10 gm of maize cob)	W3(after for 24 hours weight of moisture with 10 gms of maize cob)	Moisture content in percentage
1	31.4	41.4	40.2	12
2	28.2	38.2	37.1	11
3	28.8	38.8	37.6	12
4	29.2	39.2	38.2	10
5	29.0	39.0	37.8	12
6	28.2	38.2	37.2	10
7	26.1	36.1	35	11
8	28	38	36.8	12
9	28.6	38.6	37.8	8
10	28	38	37.1	9
11	29.1	39.1	37.9	12
12	28.7	38.7	37.6	11

TABLE VI KERNEL LOSSES

Serial No.	Before Shelling	After Shelling	Losses
1	480	471	9
2	525	515	10
3	417	408	9
4	467	461	6
5	440	432	8
6	459	452	7
7	576	566	10
8	525	517	8
9	456	450	6
10	501	498	3
11	439	432	7
12	440	435	5

TABLE VII OUTPUT OF MAIZE SHELLER BY DIFFERENT METHOD

Serial no.	Manual hand shelling (Kg/hr)	Manually operated rotary maize shelling(kg/hr)
1	2.76	5.0
2	2.8	5.9
3	2.78	5.8
4	2.82	6.0
5	2.83	6.1
6	2.85	6.3
7	2.73	5.3
8	2.78	5.5
9	2.75	5.6
10	2.71	5.1

D. Ergonomic Evaluation

First the local maize variant is collected and dried in the sun for around 3 weeks.

Before the shelling operation starts for evaluation, resting heart rate of both the subject is recorded.

Both manual and machine shelling operations starts as machine shelling did by female and manual shelling is by male and vice versa.

After shelling, immediately the working heart rate of the subjects is recorded and after 10 minutes the recovery heart rate is recorded.

Both manual and machine shelling data was collected and compared to find time taken and heart rate reserve.

A local maize variant was collected and sun-dried for 2–3 weeks.

We started the shelling operation to get the kernels and access the units while working.

The kernels are then kept in a moisture content box, each filled with 5-10gms (for both the 5 maize and 12 maize experiments), and weighed.

We then dried the maize in a hot air oven for 24 hours at 97°C. After 24 hours, we weighed the moisture content box with the kernels. Then the moisture content was calculated to find the suitable moisture content range for the local variety of maize that can be used for this machine.

Physical work capacity – It is described as the ability to perform work or quantity of work performed at a particular set of physiological parameters.

Physiological parameters –

Heart rate – It is determined as number of withdrawal (heart beat) of heart in brief it is communicated as contraction each minutes.it is expressed as beats per minutes.

Heart Rate Maximum – It is the highest number of times your heart can contract in one minute or heart rate of person could achieve during maximum physical exhaustion.

$HR_{max} = 220 – age$

Resting Heart Rate – When we are rest for at least 5 mins the heart beat about to be 60 – 80 times per minute. The resting heart rate usually increases with the age and lower in physically fit people.

Recovery Heart Rate – This is the drop-in heart rate after ceasing the activity is measured after 10 mins of completing the task or work.

Heart Rate Reserve – It is the term used to describe different between maximum heart rate and resting heart rate.

Heart Rate Delta – The difference between the heart rate working and heart rest.

Body Surface Area (BSA) – The surface area of the whole body is required to find the energy metabolism of the worker

$BSA = 0.007184 \times W^{0.425} \times H^{0.725}$

Body Mass Index (BMI) – It is a person's weight in kg/height^2

The experiment was performed with 5 maizes one male and one female

TABLE VII INFORMATION ON OPERATORS

Operator	Arati swain(female)	Alok Pradhan(male)
Age	35	18
Weight (in kg)	47.6	62.4
Height (in ft)	5	5.8
BSA	14191	17730
BMI (Kg/m^2)	20.49	19.96
Heart Rate Rest(bpm)	68	76
Heart Rate Working(bpm)	75	82
Heart Rate Recovery(bpm)	68	76
Heart Rate Maximum (bpm)	185	202
Heart Rate Reserve(bpm)	110	120
(Delta) Heart Rate(bpm)	7	6

This experiment was performed with 12 maizes one male and one female

TABLE VIII Information On Operators

Operator	Arati swain(female)	Sankar Behera(male)
Age	35	45
Weight (in kg)	47.6	48.1
Height (in ft)	5	5
BSA	14191	14254
BMI (Kg/m^2)	20.49	20.70
Heart Rate Rest(bpm)	76	60
Heart Rate Working(bpm)	83.4	68.6
Heart Rate Recovery(bpm)	76	60
Heart Rate Maximum(bpm)	183.4	175
Heart Rate Reserve(bpm)	108.4	106.4
(Delta) Heart Rate(bpm)	7.4	8.6

Fig.8 manually shelling of maize by male

Fig.9 manually shelling of maize by female

Fig.10 manually shelling of maize by rotary maize sheller (male)

Fig.11manually shelling of maize by rotary maize sheller (female)

Fig.12 Pulse meter reading female subject

Fig. 13 Pulse meter reading male subject

Fig. 16 Hot air oven with moisture content box

Fig. 17 Moisture content box with 12gms of maize in each

Fig. 14 Unshelled maize 1-6

Fig. 15 Unshelled maize 7-12

E. Cost Estimation

Angle	No.	Materials	Price
Flat	8	Iron	Rs 560(1kg = Rs 80) (7kg = Rs 560)
Bearing	7	Iron	Rs 400(1kg = Rs 80) (5kg = Rs 400)
Screw	4	Iron	Rs 4 (Rs 1/piece)
Screw with bolt	4	Iron	Rs 8 (Rs 2/piece)
Medium nut bolt (12 no. bolts (12mm))	8	Iron	Rs 40
Large nut bolt (17 no. bolts (17mm))	12	Iron	Rs 96
Small nut bolt (10 no. bolts (10mm))	2	Iron	Rs 8
Handle	1	Iron	Rs 20
Rod (30cm)	1	Iron	Rs 80
Bearing cup	2	Iron	Rs 854 (Rs 427/piece)
J plate	3	Iron	Rs 800
Octagonal rotatable hollow cylinder	1	Iron	Rs 300
Maize	27		Rs 740
Pulse meter	1		Rs 1200
Machinist cost	Cutting – 3 Welding – 12		Rs 725 (paint/lit = Rs 300) (welding/joint= Rs15) (Cutting = Rs 15) (Labour fee = Rs 1000)
			Total = 6785

III. RESULT AND DISCUSSION

In the 1st 5-maizes experiment, the maize had high moisture content which caused a lot of grain losses.
During the 2nd 12-maize experiment, we found out that a moisture content of 10 to 12% or below 10% is the right amount.
Which allowed it to reduce the grain loss to a very minimum amount.
In both the experiments the recovering and resting heart rate are both equal.

We have shown the physical properties of maize in table I
We found the average length of the cob to be 16.4cm.
The deviation of the average length from the maximum length is 3.1cm and from the minimum is 2.4cm
We found the average top width of the cob to be 4.24cm
The deviation of the average top width from the maximum top width is 4.7cm and minimum is 3.5cm
We found the average thickness to be 12.56cm
The deviation of the average thickness from the maximum thickness is 15.4cm and minimum is 6.4cm
We found the average bottom width to be 3.86cm
The deviation of the average bottom width from the maximum bottom width is 4.2cm and minimum is 3.7cm
We found the average moisture content to be 17.4%
We found the average kernels lost to be around 248
We have shown the physical properties of maize in table IV
We found the average length of the cob to be 16.6cm
The deviation of the average length from the maximum length is 17cm and minimum is 14.5cm
We found the average top width of the cob to be 3.9cm
The deviation of the average top width from the maximum top width is 4.3cm and minimum is 3.5cm
We found the average thickness of the cob to be 14.1cm
The deviation of the average thickness from the maximum is 15.5cm and minimum is 13cm
We found the average bottom width of the cob to be 2.7cm
The deviation of the average bottom width from the maximum bottom width is 3.8cm and minimum is 1.7cm
We found the average moisture content to be 10.83%
We found the average kernels lost to be around 7

Fig. 18 Shelled cobs 1-6

Fig. 19 Shelled cobs 7-12

Fig. 20 Shelled kernels of each maize 1-12

IV. CONCLUSION

From the above experiment, we have concluded that when we do it manually, it takes more time and effort. The time it takes to be done via manual shelling is at least 2 minutes, and in machine shelling it takes less than 1 minute.

During the above experiment, we find out that if the moisture content is within 10-12% or <10%, the maize can be shelled easily with very less breakage and with better shelling efficiency and very less kernel losses.

After the ergonomic evaluation we come to the conclusion that it does not affect the health of the workers involved as their recovery heart rate was equal to resting heart rate.

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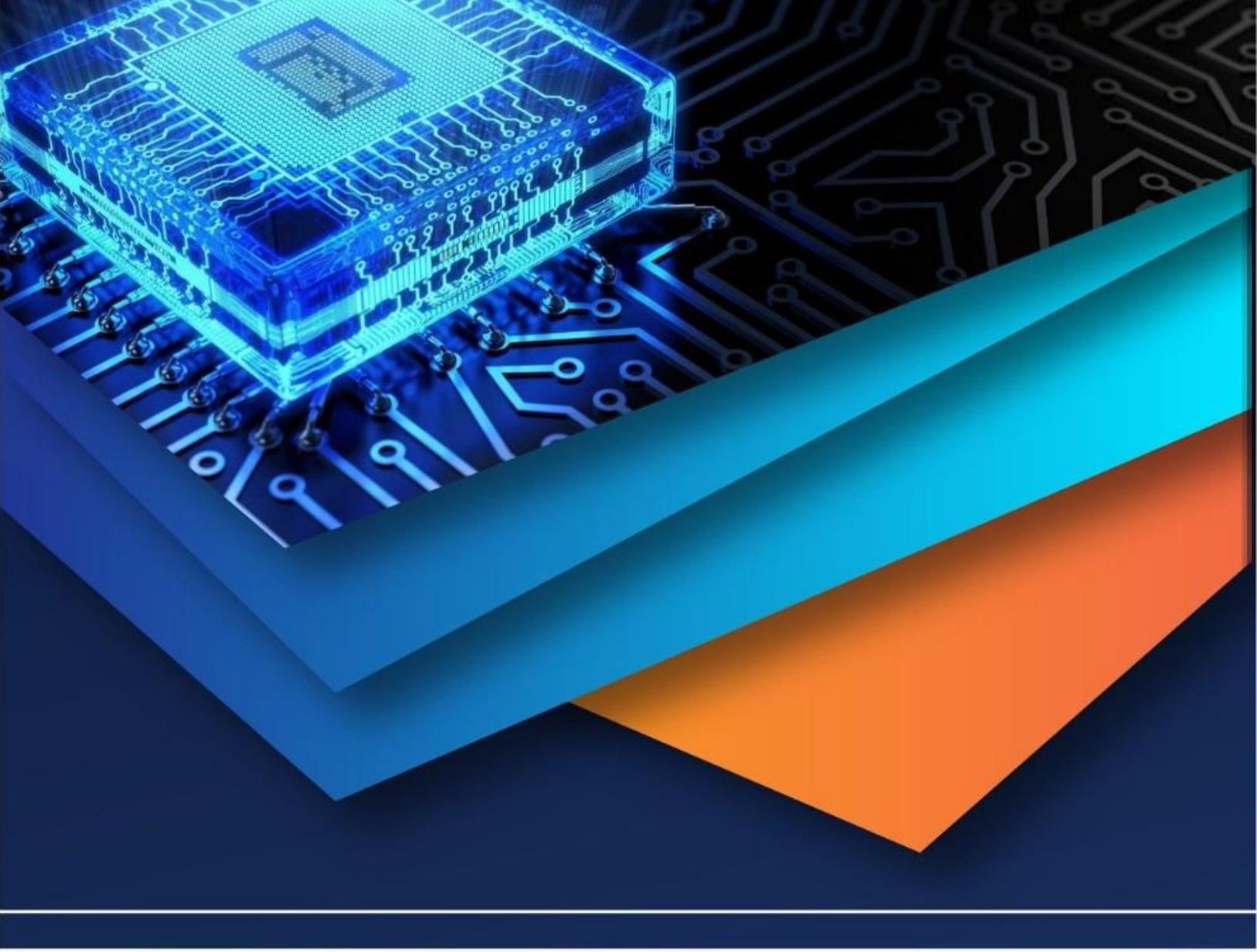

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