International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 11 | Nov 2018 www.irjet.net p-ISSN: 2395-0072

DESIGN AND DEVELOPMENT OF AN OFADA RICE HULLING MACHINE

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Abstract - *This report is on the design and construction of a rice hulling machine. Essentially the hulling machine is to enhance faster and less tedious process of removing chaffs from paddy rice. The key components of the hulling machine are the hopper, upper half cylindrical shaped body, huller, hulling knife, lower half cylindrical shaped body assembly support and petrol engine. The hopper is a frustum of a rectangular pyramid shape used to feed the paddy rice into the huller. The upper half cylindrical shaped body has an opening where the paddy rice from the hopper enters the huller. Both the hopper and the upper half cylindrical shaped body were made from 1mm thick mild steel. The hulling removes the chaffs from the rice. It was made of a pair of hulling cylinders each of length of 255mm with the outside and inside diameter of 110mm and 81mm. respectively. A hulling shaft of 40mm diameter made of mild steel material drives or rotates the hulling cylinders. The hulling knife in combination with the hulling cylinders allows the separation of the chaffs from the paddy rice. The hulling knife was made of cast iron. The lower half cylindrical shaped body has an opening to allow the exit of the dehusked rice and a sieve or mesh for the separation of the rice grains from the chaffs. The sieve was made from copper materials. The upper half cylindrical shaped body and the lower half cylindrical shaped body form the cylindrical shaped housing that accommodates the hulling unit. The assembly supports serves as a convenient platform on which the huller is mounted. The support was made of pieces of angle iron (mild steel) of 30mm by 3mm thick joined by arc welding. The assembly was mechanically welded to the cylindrically shaped housing. Based on the design consideration and analysis of mass of materials and the maximum paddy rice to be fed into the cylindrical shaped housing, the input power required to drive the hulling unit was 1.5hp and hence the nearest available petrol run engine rated 5.0 hp at 1520rpm was used. Speed reduction was achieved by the use of pulley/belt arrangement. Series of tests run on the machine show that the machine has the capacity of dehusking 5kg of paddy rice in mean time of 2.34 minutes. The machine has a hulling efficiency of 64.8%.*

Keywords: **design, development, hulling, machine, Ofada**

1.0 INTRODUCTION.

Rice is a staple food in Nigeria, and can be grown in almost all states in Nigeria and quite easy to cook. A grain of paddy is oval in shape with 1.5mm long and 0.9mm wide. The average grain size and specific gravity are 1.18 and 1.47 respectively. Paddy has a brown shell and can be dehusked faster when it is dry. Although, its protein content is similar to that of other grains, such as millet, it contains amino acid like Methionine, Riboflavin (vitamin B2) and Niacin (vitamin B3) in addition to carbohydrates which are of high nutrients and essential to human health (Luka, 2009).

Milling is a critical step in post-harvest processing of rice. The basic objectives of a milling system is to remove the husk and bran layers, and produce and edible white rice kernel that is sufficiently milled and free from impurities. Most rice varieties are composed of roughly 20% rice hull, 11% bran layers and 69% starchy endosperm, also referred to as the total milled rice. Total milled rice contained whole grains or head rice and broken. The by-products in rice are rice hull, rice grain rice germ and bran layers and fine broken (Farouk and Zaman 2012) Traditional method of hulling involves the use of mortar and pestle. it is tedious and has low efficiency as reported by Bisen, Ramawat Khorpe and Chaudary, (2014) Traditional method of hulling Ofada rice is not only laborious, also rice hulled through this method usually have stones due to the unhygienic environment where the hulling process is done, which predisposes consumer to health risk such as appendicitis as well high breakage of rice during the hulling process. Besides, there is bottleneck in rice hulling which makes it herculean to meet the increasing demand in rice consumption in Nigeria. As a result, preference for foreign rice smuggled through Nigeria porous border is high among Nigerians, which is detrimental to revenue generation of the government. This need has made it necessary to design and fabricate an Ofada hulling machine made with materials sourced locally, that will run on gasoline engine as electricity in Nigeria is epileptic and in particular most rural areas where this project is of high importance are not connected to national grid The objective of this research therefore, is to reduce human effort in rice processing, produce rice that is free of stones, and meet the increase in rice demand in Ogun State and by extension in Nigeria as well as empower rural farmers by increasing their income for growing more ofada rice locally.

2.0 LITERATURE REVIEW.

2.1 Name of Rice Grown in Nigeria According to Locality

There are a lot arable land in Nigeria that supports the rice farming across the length and breadth of the country. Rice grown in Nigeria are named according their locality. For instance, rice grown in the Kano State is referred to as Umza rice, Gombe as Mas rice Kebbi as Lobana rice, Anambra as Anambra rice, Nassarawa as Olam rice, Ekiti state as Igewu rice Kebbi and Lagos as Lake rice, and Ogun state as Ofada rice

Ofada rice is a name for heritage varieties of rice grown in South-west Nigeria. It is used in a variety of dishes. Ofada rice is mostly blend and some of rice varieties that are not indigenous to Africa; however, they usually contain African rice. It is named after the town Ofada in Ogun state. Ofada rice is mostly blend and usually contain Oryza Glaberrima (African Rice) as well as the most common type of Oryza Sativa (Asian rice) and may be categorized as either brown/red Ofada or white Ofada on the basis of its seed color, grain size , shape and shade. Ofada rice is usually unpolished because most African rice is more difficult to mill and polish, some or the entire rice husk is left on the grain, strengthening the flavor and making it more nutritious.

2.2 Methods of Hulling Paddy

Four ways of hulling rice will be explained in this section.

2.2.1 Traditional Method.

Traditional method of hulling rice is most common and employed in areas in removing chaff from paddy. Luka (2009) and Poonam, (2014) described the traditional method of hulling is done by pouring the paddy into mortar and pestle and head stone. The separation of chaff from grain is done is by washing in water or winnowing. This method takes I hour to dehusk 1kg to 2kg of paddy. It was reported by Bisen, Ramawat Khorpe and Chaudary, (2014) that it has a very low efficiency and an average of 2-3 hours is expended daily until the chaffs are removed.

2.2.2 Pedal Powered Rice Miller.

Bisen et al., (2014) designed and developed a mini milling rice hulled that operates on pedalling of bicycle since electricity is hardly available in rural settings. The performance evaluation carried out showed that the developed machine has a throughput capacity of 25kg/hr with an average milled efficiency of 85% which is an advancement over the traditional method.

2.2.3 Mechanical Method.

Meghashyan, Yuvaray and Manu (2014) designed and fabricated a mechanical paddy dehuller with hollow drum with 4 rectangular peg welded to it. The paddy was fed with 2kg of paddy, the pegs lies in-between the horizontal bar which has an inner drum. The outcome shows that the chaff removal rate from the paddy was estimated at 75% in about 6-7 minutes. Similarly, Das and Saha (2016) studied the milling of paddy in Engleberg, Bangladesh. When 40kg of paddy was fed into the machine, it turned out 25-30kg of milled rice, 25-33% of husk and bran and a loss of 5-7%. The husking efficiency was found to be 70%.

Dhankhar, (2014) reviewed steel made huller to remove chaff from paddy in his work. He described it as more than mere huller since it can used for polishing. In earlier days the type of rice mill was very popular in most rice growing countries. The iron huller or single pass mill were notorious for breaking the paddy grain. The fine broken grain are mixed with the bran and ground rice hull. The steel husker removes the husk and whiten it in one pass. Paddy rice is fed into the machine and passed between a revolving steel shaft and a cylindrical shaped mesh screen. The machine are normally powered by a 5-20 h.p engine with totalled milled rice recovery of 53-55%.

2.2.4 Husking With Rubber Rolls

Dhankhar, (2014) described this method of hulling as one in which two rubber rollers of same diameter with breadth ranges between 150mm to 250mm and 60 to 250 mm respectively. The rolls are operated in opposite direction and the clearance between rolls depend solely on the variety characteristics of paddy in process. He noted that, with this method a hulling efficiency of 85-90% with minimum broken or cracked grains.

3.0 METHODS.

The rice hulling machine was made from mild steel. It consists of hopper, upper hulling hemisphere lower hulling hemisphere, rice collector, shaft, pillow bearing and adjustable hulling blade. The hopper is designed in a circular frustum with capacity to hold about 7-10 kg of paddy per time. The paddy slips/enters into upper hulling hemisphere through a small opening of 25mm fixed/welded to the upper hulling compartment under the influence of gravitational force. The upper and lower hulling hemisphere was bend to size with a bending machine after carefully measured and marked with appropriate tool to 125mm by 500mm. The shaft is made of mild steel and is 40mm diameter, 550mm long clamped to the support by a pillow bearing. The power is transmitted from petrol run engine/ prime mover rated 5.5hp and rotates at 1520rpm through a belt-pulley system with 1520 rpm. The paddy introduced into the hulling machine was weighed in the

3.1 Performance Evaluation.

Five trial runs were carried out on the rice huller. The need for ease of comparing and repeatability of the experiment or process necessitated that 1kg of paddy was fed per time. The mass of completely hulled rice, mass of chaff time taken as well as hulling efficiency were recorded in the table below.

Table 1: Outcome of Trials Runs

Trial runs	Mass of paddy rice fed mp (Kg)	Mass of completely hulled rice mh (Kg)	Mass of chaff bran layers Mb=mp-mh (Kg)	Time taken In minutes	Hulling efficiency
1	1.00	0.62	0.38	2.56	62.00
2	1.00	0.65	0.35	2.22	65.00
3	1.00	0.62	0.38	2.37	62.00
4	1.00	0.65	0.35	2.34	65.00
5	1.00	0.70	0.30	2.20	70.00
Total	5.00	3.24	1.76	11.69	

Table 2: Mass and time taken to husk paddy

Trials	Mass of paddy fed into the hulling machine mp (Kg)	Time Taken Minutes
1	1.00	2.56
2	1.00	2.22
3	1.00	2.37
4	1.00	2.34
5	1.00	2.20
Total	5.00	11.69

4.0 Discussion.

The result obtained from the performance evaluation of the rice hulling machine in table 1 indicate mass of paddy, completely hulled rice, mass of chaff and the efficiency of the hulling machine. The machine was fed with 1kg of paddy at the same operating speed of 400 rpm and the mean time to hull the paddy fed was 2.34 minutes.

The mass of paddy and chaff are indicated from five samples carried out adjudging the machine is manned by a man. This was done for reproducibility, by hulling 1kg of paddy and timing the chaff removal process. The result indicated that the mean mass of chaff is 0.352 and mean mass of rice completely hulled / hulling efficiency was 0.648. This gave an idea of mechanically hulling of paddy in respect of chaff to rice as 5:9 and that the broken rice in each instance is negligible. The time taken to completely hull the rice fed in to the hopper ranges from 2.20 minutes to 2.56 minutes. However, the mean time to completely hulled 1kg of paddy was estimated at 2.34 minutes

From table 2, the throughput capacity of the ofada rice hulling machine was evaluated. The estimated value was obtained by dividing the total mass of paddy introduced into the machine by the total time taken in minutes. The throughput capacity was 0.43Kg/min. when converted to hour, the capacity of hulling was estimated as 25.66Kg/hour.

Also, the speed of hulling considered in this research was 400r.p.m. Hence, at 400 rpm the capacity of the machine obtained and hulling efficiency was 25.66Kg/hour and 64.8% respectively. However, only one hulling speed was considered in this research. To determine optimal speed for chaff removal and hulling efficiency, further investigation is required and this will be done in the next phase of this research.

5.0 CONCLUSION

In this work, the design and development of an ofada rice husking machine has been done. The machine was powered with by 6.5 h.p petrol engine which rotates 1520 rpm. While a combination of pulley and belt are used as means of transmitting power from the prime mover and was used to achieve speed reduction to 400 rpm. The machine was tested and has husking capacity of 25.66kg of paddy in an hour with hulling efficiency of 64.8% was achieved.

6.0 RECOMMENDATION

In order to enhance the performance of the machine, it is necessary to incorporate the following suggestions into the next design and development of an ofada rice husking machine.

- A winnowing device (or blower) should be added to the rice husking machine to enhance the separation of the chaffs from the rice.
- Other speed of rotation should be investigated so as to determine the speed in which husking efficiency is optimal.
- Other materials should be experimented as hulling blade if husking will be possible at a reduced noise and vibration.

REFERENCE

[1] Bisen R.M., Ramawat R.B., Khope P.B. and ChoudaryP.S. Desgn, development and performance. evaluation of mini rice mill for domestic purpose. International Journal of Engineering Research and Technology (IJERT) vol 3 issue 10. October 2014.

[2] Das A. K., Saha C.K. and Alam M.M. Evaluation of traditional husking of rice mill. J. Agril. Mach. Bioresour. Eng. 7(1): 2016 pp41 – 46.

[3] Farouk S M, Zaman M A Improvement of Skill and Work Environment of Landless Wage Earners Engaged in Rice Processing System of Bangladesh. A Project Report Submitted to the Research and Extension in Farm Power Issues (REFPI), Department of Farm Power and Machinery, BAU, Mymensingh. 2002

[4] Luka R. Determination of some physical properties of fonio (DigiteriaIbrurua) grown in Northern Nigeia relevant to de-stoning. Abubarkar Tafawa Balewa University Bauchi,Nigeria (unpublished) 2009

[5] Meghashyam P., Yuvaraj C., and Manu R.. Design and fabrication of Paddy Dehusker. International journal of Application or Innovation in Engineering Management. Vol 3 issue 10 2014 pp 298-306

[6] Poonam Dhankhar. Rice milling. IOSR Journal Engineering. Vol 4 issue 5, 2014 p 2278-8719

APPENDIX

Nomenclature

Symbol	Definition	Unit
α	Angle of lap	deg
β	Angle of groove	deg
θ_3	Angle of contact for drive pulley	rad
θ_4	Angle of contact for driven pulley	rad
μ	Co-efficient of friction	
ρ	Density of mild steel	kg/m^3
a	Length of straight section of belt	m
C_1	Distance between the pulleys	m
C_2	Distance of center between the two pulleys	m
D	Diameter	m
D_1	Internal diameter	m
D_2	External diameter	m
H	Height	m
L	Length	m
L	Length of belt	m
m	Mass of a single unit	kg
M	Total mass	kg
n	Number of parts used	
N	Number of revolution	rpm
N_1	Speed from prime mover	rpm
N_2	Speed of driven pulley	rpm
P_O	Power output	watts
P_i	Power input	watts
P_W	Power output from prime mover	watts
t	Thickness	m
t_b	Thickness of belt	m
T	Torque	Nm
T_1	Tension in tight side of belt	N
T_2	Tension in slack side of belt	N
V	Volume	m^3
w	Width of belt	m
W	Weight	N

Table 3: Design Analysis

SN	Part name	Input	Analysis	Remark
1	Mass of driven shaft(m_1)	d_1=39mm =0.039m, l_1=500mm =0.5m ρ=7850kg/m^3	$m_1 = \rho v_1 = \rho A_1 l_1$ but $A_1 = \frac{1}{4}\pi d_1^2$ $m_1 = 7850 \times \frac{1}{4}\pi(0.039)^2 \times 0.5$ m_1= 4.689kg	m_1= 4.689kg
2	Mass of Husking cylinders	D_2=110mm = 0.11m	$m_2 = \rho v_2 = \rho A_2 l_2$ but	m_2= 15.368kg

	(m_2)	d_2= 81mm = 0.081m l_2=450mm = 0.45m ρ=7850kg/m^3	$A_2 = \frac{1}{4}\pi\,(D_2{}^2 - d_2{}^2)$ $m_2 = \frac{1}{4}\pi\,(0.11^2 - 0.081^2) \times 0.45 \times 7850$ m_2= 15.368kg	
3	Mass of Housing unit(m_c)	D_c=256mm =0.256m d_c=252mm =0.252m l_c=500mm =0.5m ρ=7850kg/m^3	l_c $m_c = \rho v_c = \rho A_c l_c$ but $A_c = \frac{1}{4}\pi\,(D_c{}^2 - d_c{}^2)$ $m_c = \frac{1}{4}\pi\,(0.256^2 - 0.2521^2) \times 0.5 \times 7850$ m_c= 6.26kg	m_c= 6.26kg
4	Mass of Housing unit Cover plates (2) m_3	D_c=256mm =0.256m d_c=252mm =0.252m t_c=2mm = 2x10^{-3}m ρ=7850kg/m^3	$m_3 = 2\,\rho v_c = 2\rho A_c t_c$ but $A_c = \frac{1}{4}\pi\,D_c{}^2$ $m_3 = (\frac{1}{4}\pi\,(0.256)^2 \times 2\times10^{-3} \times 7850) \times 2$ m_3 = 1.616kg	m_3 = 1.616kg
5	Mass of pulley(Driven) m_p	D_p=114mm = 0.114m d_p=30mm = 0.03m t_p=36mm = 0.036m ρ=7850kg/m^3	$m_p = \rho v_p = \rho A_p t_p$ but $A_c = \frac{1}{4}\pi(D_p{}^2 - d_p{}^2)$ $m_p = \frac{1}{4}\pi\,(0.114^2 - 0.032^2) \times 0.036 \times 7850$ m_p = 2.685kg	m_p = 2.685kg
6	Mass of shaft, Housing unit, pulley (m)	m_1=4.689kg m_2= 15.368kg m_3= 1.616kg m_c=6.264kg m_p= 2.685kg	$m = m_1 + m_2 + m_3 + m_c + m_p$ m= 4.689 + 15.368 + 1.616 + 6.264 + 2.685 m= 30.622kg	m= 30.622kg
7	Mass of rice in The housing	D_2=110mm = 0.11m	$m_R = \rho v_R = \rho A_R l_c$ but	m_R = 12.112kg

	unit (m_R)	d_c=252mm =0.252 l_c=500mm =0.5m ρ_R=600kg/m^3	$A_R = \frac{1}{4}\pi(d_c^2 - D_2^2)$ $m_R = \frac{1}{4}\pi(0.252^2 - 0.11^2)$ x 0.5 x 600 m_R = 12.112kg	
8	Total mass of Driven shaft + Housing unit +pulley + rice (m_T)	m= 30.622kg m_R=12.112kg	m_T = m + m_R m_T = 30.622 + 12.112 m_T = 42.734kg	m_T = 42.734kg
9	Total weight on load (W)	W = m_Tg m_T=42.734kg g = 9.81m/s^2	W = 42.734 x 9.81 W =419.221N	W =419.221N
10	Torque on load (T)	T=wR_c W=419.699kg R_c= 0.128m	T=wR_c T= 419.699 x 0.128 = 53.660Nm	T= 53.660Nm
11	Power required (p_o)	T= 53.660Nm N= 120rpm p_o = T x ω	p_o = T x ω $\omega = \frac{2\pi N}{60}$ $p_o = 53.660 \times \frac{2\pi 120}{60}$ =674.311watts	p_o=674.311wats
12	Power from prime mover (p_i)	p_o=674.311 watts Efficiency of machine (η_m) =65%= 0.65	$p_i = \frac{PO}{\eta m}$ $p_i = \frac{674.311}{0.65}$ = 1037.40watts	p_i=1037.40wats
13	Power input in Horse power (P_{hp})	Pi=1037.40 watts	$P_{hp} = \frac{Pi}{746} = \frac{1037.40}{746}$ = 1.4hp	P_{hp} = 1.4hp Decision: a petrol engine with a capacity rated above 1.5hp is chosen. Average engine capacity is 2.5hp @ 1520rpm
14	Velocity ratio of belt drive (N_2)	D_p = 114mm = 0.114m D_{pm} = 53mm 0.053m N_1= 1520rpm N_2=?	$\frac{Dpm}{Dp} = \frac{N2}{N1}$ $\therefore N_2 = \frac{Dpm \times N1}{Dp} = \frac{0.053 \times 1520}{0.114}$ = 707rpm	N_2= 707rpm

15	Length of Straight section of belt (a)	C_1=600mm =0.6m R_{pm}=0.0265m R_p=0.057mm =0.057m	$a = [C_1^2 - (R_{pm} - R_p)^2]^{½}$ $a = [0.6^2 - (0.0265 - 0.057)^2]^{½}$ a = 0.599m	a = 0.599m
16	Length of belt (l)	R_{pm}=0.0265m R_p=0.057m a=0.599m	$L = 2a_1 + \pi R_1 + \pi R_2$ $=2(0.599) + \pi 0.0265 + \pi 0.057$ = 1.460m	L=1.460m
17	Velocity of prime mover (V)	D_{pm} =0.053m N_1 = 1520rpm	$V = \omega R = \frac{\pi D_{pm} N_1}{60} = \frac{\pi(0.053 \times 1520)}{60}$ =4.218m/s	V= 4.218m/s
18	Power output from prime mover (P_W)	Average Engine capacity =2.5hp @1520rpm	P_W = 2.5 X 746 = 1865 watts	P_W = 1865 watts
19	Difference in tension	P_W=1865wats V=4.218m/s n=2	$P_W = (T_1 - T_2)V \times n$ $\therefore T_1 - T_2 = \frac{P_W}{V \times n} = \frac{1865}{4.218 \times 2} = 221.076N$	$T_1 - T_2$ =221.076N
20	Tension in slack side of belt (open)	T_1=221.076+ T_2 μ = 0.3 β =17° θ =π	$\frac{T1}{T2} = e^{\mu\theta \mathrm{cosec}\beta}$ $\therefore \frac{221.076 + T2}{T2} = e^{0.3 x \theta x \mathrm{cosec} 17}$ $\therefore 221.076 + T_2 = 25.117T_2$ $221.076 = 25.117 T_2 - T_2$ $221.076 = 24.117 T_2$ $T_2 = \frac{221.076}{24.117} = 9.167N$	T_2= 9.167N
21	Tension in tight side of first belt	T_2 = 9.167N	$T_1 = 221.076 + T_2$ $T_1 = 221.076 + 9.167 = 230.243N$	T_1= 230.243N
22	angle of lap	D_p=114mm =0.114m D_{pm}=53mm =0.053m C_2=650mm =0.65m	$\mathrm{Sin}\ \alpha = \frac{Dp - Dpm}{2C2} = \frac{0.114 - 0.053}{2(0.65)} = 0.0469$ $\alpha = \mathrm{Sin}^{-1} 0.0469 = 2.7°$	α = 2.7°
23	Angle of contact for drive pulley	α=2.7° = 0.047rad	$\theta_3 = \pi - 2\alpha = \pi - 2(0.047) = 3.048rad$	θ_3 =3.048rad

24	Angle of contact of driven pulley	α=2.7° = 0.047rad	$\theta_4 = \pi + 2\alpha = \pi + 2(0.047)$ =3.048rad	θ_4 =3.048rad
25	Volume of belt	w=13mm =0.013m t_b=8mm =0.008m	Vol= Area x Height = w x t x 1 m Vol = 0.013 x 0.008 x 1 = 1.04x$10^{-4}$$m^3$	Vol=1.04x$10^{-4}$$m^3$
26	Mass of belt (m_b)	ρ_b= 1185kg/m^3 Vol= 1.04x$10^{-4}$$m^3$	$m_b = \rho_b$ x vol = 1185 x 1.04x10^{-4} = 0.11856kg	m_b = 0.123kg

Plate !: Rice Hulling Machine

Plate 2: Rice Hulling Machine