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ABSTRACT
A 3 tones per day capacity Rice Processing plant was established for the Burma Farm in Bayelsa State. The installed machines are: one Rice Thresher, one Wet Cleaner, three Rice Parboilers, one Rotary Steam Dryer, four Milling Machines and one Preumatic Cleaner. All the machines were fabricated in the National Cereals Research Institute Badeggi, with funds provided by the Nigeria Agip Oil Company Ltd. Port-Harcourt. The performance of each of the machines were evaluated and their results were recorded. The Milling recovery of the plant was observed to be 69.5% - 70.43% while the performance of the various components of the plant are clearly highlighted.

Keywords: *Burma, Rice, Processing plant.*

INTRODUCTION

Rice (Oryza sativa L) , which is believed to have originated from ancient china is one of the most important staple food crops for more than half of the world's population (Banayopadhay and Roy 1992). The rice seed contains about 66.4% starch, 12% iron and 26.3% amylose (Resurrection et al 1979) while it's energy and protein contents are 3.75% and 7.5% respectively (IRRI,1993).

The potential of Nigeria in rice production in terms of availability of land, market, human resources and weather is so enormous but the actual rice production level of the nation is so low that the country imports rice worth 600 – 700 million dollars annually (Guardian 2002). Recently, the per-capita rice consumption has increased from 21kg to about 29kg between 1997 and 2002. (NCRI. 1997).

In order for the nation to be self sufficient in local rice production, individuals, Corporate Organizations and both the States and the Federal Government need to efficiently utilize the available land potential of 4.6 – 4.9 million hectares (Kehinde 1997 and Idachaba 1985) available in the country. In line with this aspiration, the federal government of Nigeria inaugurated a committee to come up with strategies to increase rice production in Nigeria.

As part of effort by the Bayelsa state government of Nigeria to encourage rice production; the Burma Rice Farm was established through a collaborative effort by the the Nigeria Agip Oil Company limited Port Harcourt and the National Cereals Research Institute, Badeggi. The aim of the project was to establish a 3 tons per day Rice Processing Plant to augment the existing rice production capability of the state, provide source of avenue for local rice farmers to process their crop, provide rural employment for the unemployed youths and generally contribute to rural development in the state.

The Nigeria Agip Oil Company Limited Port Harcourt, which undertakes oil prospecting activities in Bayelsa State provided the fund for the whole project while the National Cereals Research Institute, Badeggi provided the processing equipment.

This paper therefore offers highlights on the general performance of the Burma Rice Processing Factory.

BRIEF DESCRIPTION OF EQUIPMENT IN THE PROCESSING PLANT

i. **Rice Thresher:**

This machine dislodges rice see from the harvested rice panicles. It made up of a trapezoidal hoppe threshing assembly, straw outle frame and power unit. The threshi assembly obtains power from a 10 diesel engine and is comprised of drum having studs bolted to flat ba

that are arranged longitudinally at a distance of 10cm from one another.

ii. **Reciprocatory Winnower:**

This equipment cleans threshed rice seed. It is composed of a hopper, reciprocatory sieve assembly, centrifugal blower, chaff outlet, fine impurities and seed outlets. The reciprocatory sieve assembly houses three sets of screens oscillates at a speed of 0.35m/sec.

iii. **Wet Cleaners:**

The wet cleaners washes the rice further to eliminate sand and other impurities before parboiling. They are cylindrical vessels having removable stiring assembly and drain valves. An arm is provided for the stiring assembly to be rotated manually.

iv. **Rice Parboilers:**

This equipment pretreats rice hydrothermally in order to improve the quality of the rice when milled. It has a boiler and steaming unit which are interconnected by a network of 50mm diameter pipes. Pressure relief valves and water drain valves are also connected to the boiler and the steaming units respectively.

v. **Rotary Steam Dryer:**

This machine dries parboiled rice from about 45% m.c. to 13.5% m.c. in two passes. The machine is composed of the boiler which is placed over a bricks furnace and an insulated rotary drying unit that obtains power from a 10hp electric motor. Steam is generated in the boiler at 100^0C and passed on to the rotary drying unit through a 50mm pipe to heat the rice in the rotary drum unit through heat exchangers.

vi. **Rice mill:**

The mill performs the function of dehusking and polishing dried and tempered rice. It is made up of a hopper, milling chamber, husk aspiration unit, milled rice spout and power unit. The milling chamber which rotates at about 650 – 750 reu/min with the aid of a 15hp electric motor is comprised of a milling cylinder that is housed in a half cylindrical mild steel [illegible] of screens.

PERFORMANCE ASSESSMENT

1. **Rice Thresher:**

Handful of rice weighing about 10kg is fed into the thresher through the hopper. The impact force of the drum (rotating at an average speed of 500rpm) on the rice panicles dislodges the seed from the straw. The rice staws and chaff are discharged through the straw outlet due to the spiral arrangement of the bars on the rotating drum while the threshed rice seed and some chaff are collected by gravity through the concave into the collector. The few unthreshed rice are dislodged from the panicles manually. The total threshed rice after winnowing and the unthreshed ones dislodged manually are weighed and recorded as shown in table 1. The efficiency of the thresher is also computed using the formular below:

$$\eta_{cy} = \frac{Tr}{Tr + Tu} \times 100\% \quad 1$$

Where

η_{cy} = Efficiency of thresher (%)

Tr = Quantity of threshed rice seed (kg)

Tu = Quantity of unthreshed rice seed (kg)

2. **Reciprocatory Winnower:**

The machine is put on for 5 minutes and 1000kg of threshed rice per batch is fed into the machine through the hopper with the aid of a shutter. The reciprocatory action of the screens enables cleaned seeds to pass through the upper and middle screens and discharged through the seed outlet while the straws, chaffs and stones are trapped and discharged at the front of the machine due to the combined effect of the screen movement and the centrifugal air blower. The fine impurities (sand) and rice seeds are trapped below the upper and middle screens and discharged through different outlets. The winnowed rice is weighed and further cleaned

manually. The mass of foreign materials, efficiency of the machine and output capacity were determined from first principles as shown in equations (2), (3) and (4) and the values are presented in table 2.

$$\eta_{cy} = \frac{Ms}{Ms + Mm} \times 100\% \quad (2)$$

Where:

$Ms = Mi - Mf$

$$\eta_{cry} = \frac{Mcp}{Mcp + Mlp} \times 100 \quad (3)$$

$$Cmo = \frac{Mf}{t(mins)} \times 60mins \times 8hr/day \quad (4)$$

Where:

Ms = Mass of foreign separated materials (Kg)
Mi = initial mass of paddy (kg)
Mf = Final mass of paddy (kg)
η_{cy} = cleaning efficiency (%)
Mm = Mass of manually separated materials (kg),
t = Time spent (min)
Mcp = Mass of cleaned paddy from winnower (kg).
Mlp = mass of lost paddy (kg)
η_{rcy} = Seed retention efficiency (%)
Cmo = Output capacity of machine (kg/day)

3. **Wet Cleaners:**

1000kg of winnowed rice each of faro 52, faro 35, DA 29, Faro 43, Faro 29 and Faro 24 are introduced into the cylindrical vessel containing water. The stirrer is then turned vigorously at an average speed of 30rpm for 2 minutes. The difference in specific gravity of the rice seed. chaff and other impurities enables them to be separated from one another. The lighter impurities that float on the water are removed with a plastic mesh and the stirrer is turned on again for one more minute for more lighter materials to be removed before discharging the filled grains.

The time taken for removal of the impurities are also recorded. This operational procedure is repeated with subsequent batches for about 5 to 7 times before draining the water and washing off the sand that deposited at the base of vessel. The time taken for each operation is recorded and the capacity of the cleaner is calculated. The results are presented in table 3.

$$Caw = \frac{Mp}{ta} \times 60mms \times 8\ hr/day \quad (5)$$

Where:

Caw = average capacity of wet cleaner
Mp = mass of paddy
ta = average cleaning time per batch (mins)

4. **Rice Parboilers:**

1000kg of rice each from faro 52, faro35, faro43 and faro24 from the wet cleaners are introduced into the soaking/steaming tank and soaked with water from the boiler at 70^0c. The water is drained after 8 hours and steam is passed on to the tank from the boiler and left until the husks cracks. They are then unloaded and tempered for about 8-12 hours before feeding into the Rotary steam dryer. The duration taken for the rice to crack during the steaming operation, quantity of white belly rice and colour difference of the rice were recorded as shown in table 4. The percent white belly and parboiling efficiency of the equipment were computed using the conventional relationship as shown in equations 6 and 7.

$$Wb = \frac{Mwb}{Mr} \times 100\% \quad (6)$$

$$\eta_{cy} = \frac{Mr - Mwb}{Mr} \times 100\% \quad (7)$$

Where:

Wb = Percent white belly (%)
Mwb = Mass of white belly rice
Mr = Total mass of parboiled rice
η_{cy} = Parboiling efficiency of machine (%)

5. **Rotary Steam Dryer:**

1000kg of parboiled and tempered rice each of faro 52, faro35, faro43 and faro 42 are fed into the rotary drying unit through a detachable hopper. The dryer is put on while water is heated in the boiler to generate steam. The drum with the content is allowed to rotate at 5 revolution per minute (rpm) until the moisture content is reduced from about 45.0% to 18.0% before they are discharged. The rice is then left to temper for 3 hours and re-introduced for the second pass drying for the moisture to be reduced from about 18.0% to 13.5%. The content is finally released and tempered for another 12 hours before milling. The drying times for the first and second pass for each variety are noted and recorded in table 5.

6. **Rice mills:**

1000kg each of the dried and tempered rice samples are put into the machine through the hopper while the shutter is closed. The machine is then put on for 2-3 minutes before releasing the shutter slowly for the rice to be dehusked in the first mill. They are then polished in the second sets of mills using the same procedure. The mass of milled rice, whole and broken grains for each variety are weighed and presented in table 6. The dehusking efficiency of the mill, milling recovery and percent whole grain recovery were calculated using the following conventionally established relation:

$$Mr = \frac{Mm}{Md} \times 100\% \quad 8$$

$$\eta_{cy} = \frac{Mm}{Mm + Mu} \times 100\% \quad 9$$

$$Wr = \frac{Mw}{Mw + Mb} \times 100\% \quad 10$$

Where :

Mr = Milling recovery of mill (%)
Mm = Mass of milled rice (kg)
Md = mass of dried parboiled dried rice (kg)
Mu = Mass of undehusked rice
Mw = mass of whole grain (kg)
Mb =mass of broken grains (kg)
Wr =whole grain recovery (kg)
η_{rcy} = Dehusking efficiency

RESULTS AND DISCUSSION

1. **Rice Thresher**

Results of thresing data presented in table 1 shows that the machine can thresh about 3,216 kg/day of paddy while the average quantity of unthreshed rice in a day was observed to be 0.156 kg representing 0.006% of the total processed rice. This results in an average threshing efficiency of 99.98%. No breakdown of the machine components was recorded throughout the test-running period.

2. **Reciprocatory Winnower**

The capacity of the winnower ranges from 5,290.6 kg/day – 5,970.0kg/day as shown in table 2. The variation in the machine output could be as a result of the variation in the specific gravity (density) of the rice varieties. The mass of lost seed per 1000kg of seed is also observed to range from 0.3 – 0.5% which result in seed retention and cleaning efficiencies of 99.94 - 99.95% and 86.96 – 93.33% respectively. Minimal breakdown of the reciprocatory unit of the machine was observed and was rectified.

3. **Wet Cleaners:**

It is observed from table 3 that the capacity of the wet cleaner increased with increase in the mass of paddy per batch. However, the 45kg load per batch which results in an average cleaning capacity of 1167.57kg per day was found to be the optimum loading capacity because it yielded the desired expected capacity (1000kg per day) of the equipment compared to the 60kg and 75kg load per batch. These higher loads were not quite convenient for the operator because of the high torque required to turn the stiring handle.

4. **Rice Parboilers:**

The parboiling data in table 4 indicates that it was very effective. A parboiling efficiency of 100% was

recorded, as there was no percent white belly. The observed differences in colours are as a result of the variation in the rice varieties.

5. **Rotary Dryer:**

As seen in table 5, both the initial and final drying times for different rice varieties varies. Faro 52 recorded less initial and final drying times of 150mins and 123.33mins respectively while Faro 35 had longer initial drying time of 190min. The longest final drying time of 160min was observed for Faro 24. The variation in the drying time for these rice varieties could have been as a result of their varying abilities to absorb moisture during the parboiling process.

The dryer is also capable of handling 1000kg of paddy within a total drying time of 453.33mins (7.5hours) – 516.67mins (8.6hours) per day.

6. **Rice Mills:**

The combined capacity of the two rice mills used for dehusking and polishing is observed to be 8,000kg per day. This indicates that the capacity of each mill is 4,000kg per day. The mills also recorded milling recoveries of 69.5% - 70.58%, while dehusking and whole grain efficiencies of approximately 100% each were recorded.

The colour of the milled rice was also very appreciative as the general appearance is amber yellow as shown in the parboiling data (table 4). The husk aspiration system that syphoons rice husk from the milling area and the blower that separates final rice bran from the polished rice were also very effective.

CONCLUSION

The results of the performance test of the various components of the Rice processing plant in the Burma Rice Farm clearly indicates that the machineries are efficient. The 3 tons per day expected designed capacity was practically realized and the 69.54% - 70.58% milling recovery which translates into about 97% over-all plant's efficiency is very acceptable. The maintenance and repair requirements of the machinery are also very simple since the spare parts are locally available.

The operation of all the machines do not even require highly technical expertise. The various governments of Nigeria can take advantage of this technology to popularize rice processing and enhance the productivity of farmers.

Table 1: Threshing Data

S/NO	Qty of Threshed Rice per hr. (Tr), kg	Qty of threshed rice per day (Trd), kg	Qty of unthreshed rice per day (Tu), kg	Threshing efficiency (ncy)%
1	400	3,200	0.1	99.98
2	370	2,960	0.5	99.99
3	405	3,240	0.2	99.95
4	420	3,360	0.08	99.98
5	415	3,320	0.1	99.98

Average capacity of thresher = 3.216kg/day

Table 2: Winnowing Data:

Rice variety	Initial mass of paddy (Mi), kg	Final Mass of Paddy after Winnowing (Mf), kg	Time spent on winnowing (t), min	Mass of foreign separated materials using machine machine (Ms), kg.	Mass of foreign separated materials using manual method (Mm),kg	Mass of lost paddy using machine (Mop)	Cleaning efficiency of machine (ncy),%	Seed retention efficiency (Ncy)%	Output capacity of machine (Cmo) kg/day
Faro 52	1,000	992	90	7.0	0.5	0.5	93.33	99.95	5290.0
Faro35	1,000	991.7	83	7.2	0.7	0.4	91.4	99.97	5735.13
Da29	1,000	993 7	5	5.4	0.6	0.3	90.0	99.97	5746.7
Daro43	1.000	990.3	92	8.5	0.75	0.45	91.89	99.98	5166.76
Faro 29	1.000	995.0	80	4.0	0.6	0.4	86.96	99.94	5970.0
Faro 24	1.000	899.0	76	9.2	0.62	0.38	93.69	99.94	5677.69

Table 3: Wet cleaning data

Rice variety	Mass of paddy (Mp), kg	Time spent on first agitation (tai) mins	Time taken for removal of lighter impurities (tii) mins	Time spent on second agitation (ta_2) mins.	Time spend on removal of more lighter impurities (tl_2) mins	Cleaned grains discharging time (td) mins	Total time per cycle of cleaning (tT) mins	Average time per cycle of cleaning (ta) mins	Average capacity of cleaning (Ca) kg/day
Faro 52	25	2.0	1.0	2.0	2.0	2.0	9.0	10.33	1161.67
	25	2.0	3.0	2.0	3.0	2.0	12.0		
	25	2.0	2.0	2.0	2.0	2.0	10.0		
Faro35	35	2.0	3.0	2.0	3.0	2.0	12.0	11.0	1527.27
	35	2.0	2.0	2.0	2.0	2.0	10.0		
	35	2.0	3.0	2.0	2.0	2.0	11.0		
Daro43	45	2.0	2.0	2.0	3.0	3.5	12.5	12.83	1685.55
	45	2.0	3.0	2.0	3.0	3.0	13.0		
	45	2.0	3.0	2.0	3.0	3.0	13.0		
Faro 29	60	2.0	3.0	2.0	3.0	4.5	14.5	13.83	2082.41
	60	2.0	2.0	2.0	3.0	4.0	13.0		
	60	2.0	3.0	2.0	3.0	4.0	14.0		
Faro 24	75	2.0	4.0	2.0	4.0	6.0	18.0	17.17	2396.04
	75	2.0	3.0	2.0	4.0	7.0	18.0		
	75	2.0	2.0	2.0	4.0	5.5	15.5		

Table 4: Rice Parboiling data

Rice variety	Mass of rice (Mr), kg	Soaking duration (td) mins	Steaming duration (ts)mins	Mass of white belly rice (Mwb), kg	Percent white belly Wv	Colour difference E	Parboiling efficiency (c) %
Faro 52	1000	480	45	0	0	6.3	100
	1000	480	45	0	0	6.1	100
	1000	480	48	0	0	6.5	100
Faro 35	1000	480	62	0	0	9.3	100
	1000	480	58	0	0	9.7	100
	1000	480	59	0	0	8.4	100
Faro 43	1000	480	60	0	0	7.5	100
	1000	480	60	0	0	7.0	100
	1000	480	60	0	0	6.8	100
Faro 24	1000	480	55	0	0	8.2	100
	1000	480	65	0	0	7.9	100
	1000	480	65	0	0	8.5	100

Table 5: Drying data for Rotary Steam dryer

Rice Variety	Mass of parboiled paddy (M), Kg	Initial drying time from 30% m.c to 18% m.c (ti), mins	Final drying time from 16% m.c to 13.5% m.c (tf), mins	Tempering duration between Initial and final drying (tt) mins	Tempering duration after final drying (tta)	Initial average drying time (tia), mins	Final average drying time (tfa), mins
Faro 52	600	150	120	12	12	150	123.33
	600	150	120	12	12		
	600	120	130	12	12		
DA 29	600	180	140	12	12	190	131.67
	600	190	135	12	12		
	600	200	120	12	12		
ROK 5	600	150	140	12	12	160	131.67
	600	150	120	12	12		
	600	180	135	12	12		
CK77-3-2-2	600	200	150	12	12	176.67	160
	600	150	180	12	12		
	600	210	150	12	12		

Table 6: Milling data

Rice variety	Mass of dried rice (Md), Kg	Mass of milled rice (Mm), Kg	Mass of whole grain rice (Mw), Kg	Mass of broken grains (Mb) Kg	Mass of unmilled rice (Mu), Kg	Time taken to mill sample (mins)	Average Mass of whole grain (Maw), Kg	Average Whole grain efficiency (wcy)%	Average Dehusking efficiency (dcy) %	Average Milled rice recovery (Mr)%
Faro 52	1000.0	696.8	696.4	0.3	-	58	704.53	99.97	100	70.43
	1000.0	711.3	711.1	0.2	-	62				
	1000.0	705.5	705.2	0.2	-	65				
DA 29	1000.0	690.1	689.1	0.9	-	60	696.3	99.87	100	69.54
	1000.0	703.1	702.3	0.7	-	57				
	1000.0	695.7	694.8	0.8	-	60				
ROCK 5	1000.0	715.3	714.8	0.4	-	63	706.37	99.92	100	70.58
	1000.0	708.6	708.1	0.4	-	66				
	1000.0	695.2	694.6	0.5	-	61				
CK73-2-2	1000.0	699.9	698.1	0.8	-	59	695.73	99.85	100	69.5
	1000.0	685.4	684.6	0.8	-	63				
	1000.0	702.6	701.9	0.6	-	65				

Table 4: Steam Properties

Temp. of steam (^{0}C)	Specific volu- me of steam V(m^3/kg)	Specific Int- ernal Ener- gy U(KJ/kg)	Specific Ent- halpy, h (KJ/kg)	Specific ent- hropy, S(KJ/kg^{0}K)	Density (kg/m^2)
111.7	1.148	2519.316	2693	7.0	0.8711
108	1.290	215.818	2688.227	7.288	0.7752
1.4.5	1.433	2510.568	2682.64	7.302	0.6978
101.8	151.6	2509.259	2679.074	7.333	0.6345

Table 5: Protein Contents

Rice	Replications	Protein Content	Average Protein Content
Faro 21	1	8.8	9.37
	2	9.8	
	3	9.5	
Faro 27	1	6.8	7.77
	2	8.0	
	3	8.5	
Faro 29	1	7.5	6.77
	2	6.0	
	3	6.8	
Faro 35	1	9.2	9.0
	2	8.7	
	3	9.1	

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