1.0 INTRODUCTION

1.1 Background

Rice provides food for nearly half of the world's human population. During the last decade, the world rice production has increased by 28%. This is mainly due to the increase in production of rice in the developing countries.

In Kenya it is grown in large scale in Mwea and Ahero irrigation schemes and in semi large-scale quantities in other irrigation scheme like Tana and Pekkera irrigation schemes.

The scheme covers over 5000 acres of land 500 private individual lands dedicated to growing of the paddy hence making paddy growing the main economic activity in the region mainly from selling of the rice casual laborers in the fields.

Ahero irrigation scheme is a government initiated scheme which leases irrigation lands to both small scale and large scale farmers to encourage both local and non-local people to engage rice growing. The scheme was initiated in 1984 with the construction of the irrigation canals and bands to enhance irrigation of the wetland fields with water from river Nyando.

Drying of paddy in artificial or mechanical dryers costs 5 to 8 times more than sun drying (Martin Gummert). This figure should be placed within the context.

The farmers rent the fields at about ksh20, 000 an acre for a single season and this can have returns of up to ksh120, 000 without the post-harvest losses hence ideally lack of a commercial paddy dryer is the major setback. The scheme has proved not to be economically viable to the

Farmers due to the post-harvest losses incurred when handling the produce from the farms. Generally the board doesn't accept wet paddy straight from the farms mostly because the rice mill doesn't have a paddy dryer incorporated within itself, this therefore impose to the farmers the hardship of sun drying the grains.

This could be up to 40sacks from a single acre to optimum moisture content of 14% which is the required failure to which a very minimal output is archived by the farmer as quality grains and the rest as broken rice which is mostly used agricultural feeds. Generally sun drying takes from one to two weeks in a fair weather conditions.

1.2 problem statement

Rice is extensively studied for agronomical characteristics, production practices, chemical composition kernel structure, post-harvest behavior, and storage practices. However, information on post-harvest losses has not been adequately reviewed.

The farmers at Ahero irrigation scheme rent the fields at about ksh20, 000 an acre for a single season and this can have returns of up to ksh120, 000 without the post-harvest losses hence ideally lack of a commercial paddy dryer is the major setback. The scheme has proved not to be economically viable to the farmers due to the post-harvest losses incurred when handling the produce from the farms. Generally the board doesn't accept wet paddy straight from the farms mostly because the rice mill doesn't have a paddy dryer incorporated within itself, this therefore impose to the farmers the hardship of sun drying the grains.

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The main post harvest losses incurred are:

- Weight loss (quantity)
- Nutrition loss
- Damage
- Loss in viability of the seed.
- Quality loss

News article

(ABOUT 2000 small scale farmers in Ahero and Kabonyo rice schemes in Nyando district are stuck with close to 400 metric tons of rice, which they cannot sale because there is no buyer interested in their produce) www.jaluo.com

this problem manifested itself because nearly 1/3 of the processed rice were broken rice which is poor quality according to the buyers and can fetch very minimal amounts that was rejected by the farmers, this problem can be eliminated by uniformly drying the paddy.

1.3 Justification

Mechanical dryers are therefore the ideal driers because of the uniformity of drying, they also minimize post-harvest losses and very minimal time is required during drying. Drying is an important part of the processing cycle, although harvesting is not season bound hence depending on solar drying frustrates rice farmers, designing of a high temperature cascade type drier which can dryer capacity of at least 2tons/hr, the moisture removal is faster. The maximum temperature of required for drying paddy with moisture content of up to 20% should be 44 degrees and 40 degrees for paddy with over 20% moisture content and this heat can be harvested from the parboiling chamber.

1.3.1 Assessment of drying losses

Drying losses are assessed by calculating the difference in weight of the grains before and after drying on a standard moisture basis. The magnitudes of the losses caused by:

birds, rodents, insects, and pests during tradition sun drying, however, varies greatly and have little significance in estimating the overall grain losses due to drying. The loss in weight due to moisture is not tobe taken as loss.

In paddy, losses are influenced significantly by the drying techniques. Paddy is usually dried in yards under hot sun or in batch or continuous-flow driers. The efficiency of drying influences the nature of cracks and subsequent milling breakage if the optimum 14% moisture content is not achieved.

The table below is simply showing that at 14% moisture content gives the highest yield of 61.67% with a very minimal loss due to broken kernels of 6.08%, hence 14% m.c should be maintained for best milling yields.(Obtained from, IRRI)

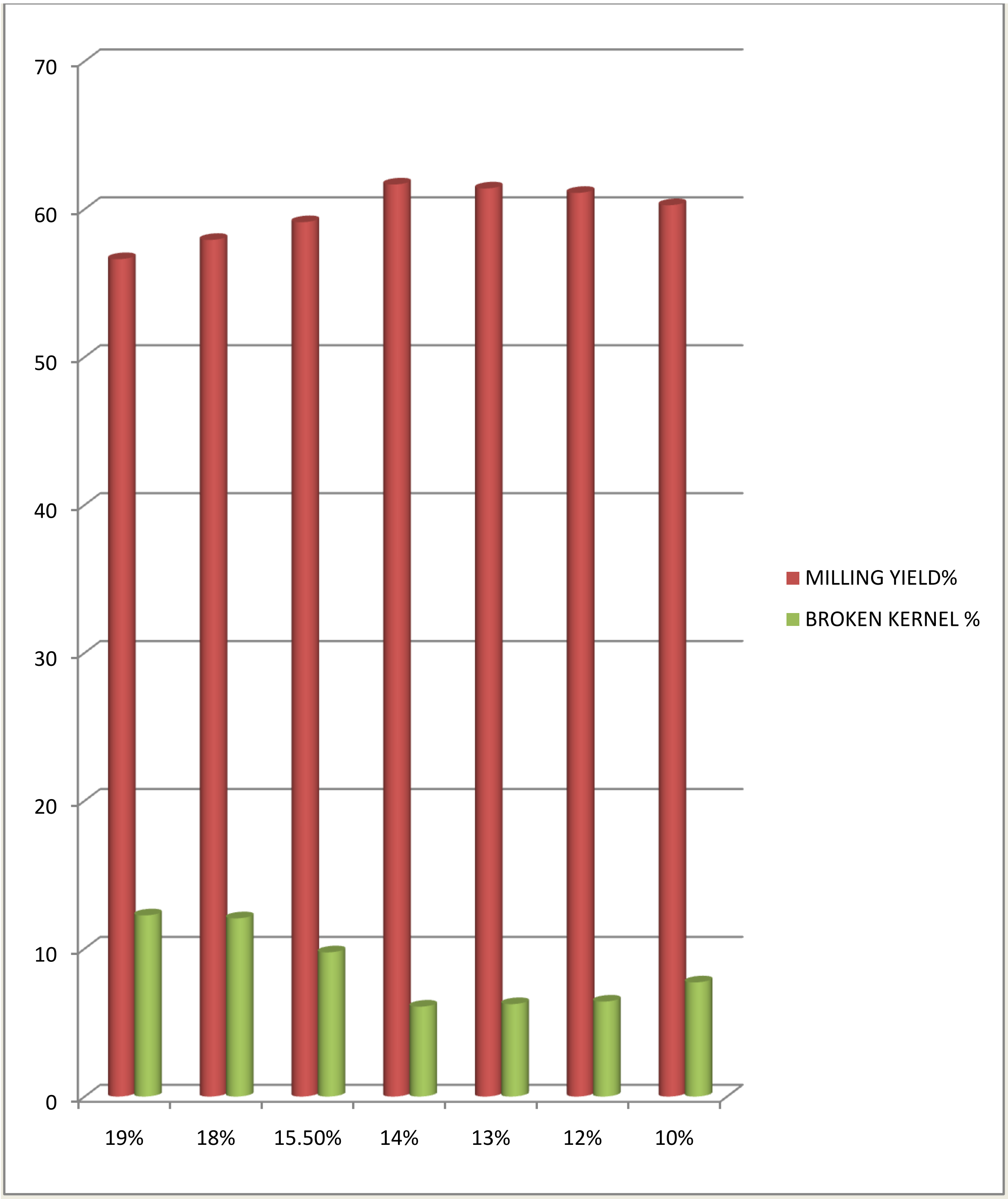


table 1. <u>Table of milling yield against moisture content</u>

The Cascade type dryer is a very effective tool for installing the rudiments of grain drying. The fan's performance curve can be plotted to explain air flow volume versus the resistance of the grain mass.

The heating of the drying air and the drying process can be graphed on a psychometric chart. The effect of drying air temperature on drying rate and milling quality can be demonstrated.

The fuel utilization efficiency to dry the moisture load can also be measured.

1.4 Objectives

To design a cascade type paddy dryer that would help eliminate post harvest losses incurred by farmers at the Ahero irrigation scheme

The minimization or elimination of these losses would have the following advantages:

I. The food supply can be significantly increased without bringing another acre of land into cultivation and additional expenditure on energy, water and capital.
II. The wastage of energy used to produce and market the lost food will be eliminated.
III. The problem of garbage disposal and consequent pollution will be reduced greatly.
IV. Consumers need will be satisfied, and better nutrition will be ensured with the same amount of non-renewable resources such as land, water, energy and labor.

1.4.2 Specific objective

- To determine the types of losses incurred by the farmers at the Ahero irrigation scheme.
- Help the eliminate the post harvest losses incurred by the farmers at the Ahero irrigation scheme

2.0 LITERATURE REVIEW

2.1General overview

2.1.1 Paddy drying in Ahero and Kenya in general

Due to slow rate of economic development in Kenya the commonly adopted method of paddy drying that is widely practiced is definitely open air/sun drying. Sun drying is the traditional method of drying the harvested rice crop. The crop is either left in wind rows in the field to dry (after reaping but before threshing), or spread out on mats or on pavements after threshing. During the wet season, if there is no artificial drying capacity, it is not uncommon for the grain to sprout and rot before it can be dried. If there is any delay in drying the wet grain the result is darker coloration, compared to the summer crop that can be sun dried immediately after harvesting and has a whiter and brighter luster.

2.1.2 Drying of high moisture paddy

Drying remains the key problem: Martin Gummert , declares that paddy drying is the problem in rice post-harvest. Drying notes Martin, is much more difficult compared to farm automation because use of mechanical dryers often requires adaptation of technology into an existing post-harvest system. Further, the drying process is a complicated process involving air and crop properties, which require a deep knowledge of the process. It is a challenge to engineers and as a result so many have been involved in seeking solutions that there are many prototypes of dryer which work technically in the labs. Martin adds that users of the newly designed dryers have not continued their use for various reasons. This is not due to lack of research on the topic; perhaps the problem analysis has not been satisfactory. IRRI

Sun-drying:

The sun may not be available when it is most needed; if it rains for a week during harvest time the grain is likely to germinate, yellowed or rotten; when there is sun shine in the morning and the grain is spread out, a sudden rain storm can cause fissured grain; if the sun is hot, the workers prolong mixing the grain and the result again will be fissured grain. A miller interviewed in Laguna, Philippines, said that despite the greater expense of drying rice in their heated air dryers (estimated cost 5 times more), they could not afford to sun-dry anymore because of the damage to grain quality is more expensive for them. Dwayne Sutter who has had long experience in the Philippines, says states sun drying of paddy is a major cause of lower head rice[2] yield. Sun drying was usually a single pass operation, which did not allow the grain to go through a tempering phase to relieve internal stresses. As a result, small fissures were formed. These defects are not visible to the naked eye but can be observed by shining a light through the grain. During years when they experienced late afternoon rains in the harvesting season, they correlated this weather pattern with the low head rice yields obtained.

Flat-bed dryers: The flat bed dryer configuration is the most basic design. A review of the literature indicated that before World War II, grain in the Southern U.S. was dried in barns designed as flat bed dryers. A flat bed dryer is basically a perforated sheet floor above a plenum chamber, where the grain to be dried is placed about a foot deep. Heated air is forced through the grain mass from the plenum below the bed. The grain is loaded and unloaded from the drying bed manually. When the farm boys left to go to war, shrinking the labor force, U.S. agricultural engineers designed mechanical grain silos. This was the first application of column dryers loaded by bucket elevators.

Re-circulating dryers from Japan or Taiwan.

At first gland these dryers look like flimsy toys. These are silos available in 1,2 and 5 ton batch capacities. It contains a drying section (usually two columns) with a feed tank above it. It has unloading rollers and an auger at the bottom to direct the gain into the intake hopper of a bucket elevator that feeds the grain back into the top. The drying section is equipped with a suction fan. They drying air is heated directly (no heat exchanger) by a vaporizer with a kerosene burner. The heart of the operation is an in-line moisture meter that measures the moisture content of the grain as it posses through the drying section. After the dryer is loaded, fan started and burner ignited, the grain is re-circulated through the dryer. The feed tank serves as a tempering bin. When the grain reaches 14%, the dryer is shut off and the grain is unloaded.

Fluid-Bed Drying: Over in Thailand at the King Mongkut Institute of Technology, Dr. Somchart Soponronnarit's group, with and UNSW collaboration, were busy learning about in-store drying and developing a fluid bed dryer for the first stage. A Thai miller has successfully adopted his bulk warehouse for in-store drying. There may be others by now. The miller built air ducts flush with the floor to allow free movement of his payload to load and unload grain from the warehouse.

3.0 MATERIALS AND METHODS

3.1 Assessment of the Ahero irrigation scheme

The conclusive data of the area of the irrigation scheme was obtained from (National Irrigation Board of Kenya & Ahero Irrigation Board), which enabled me to calculate the seasonal yield having acquired the data from (FAO) pertaining area yield per hectare in Africa.

The scheme covers over 5000 acres of land 500acres private individual lands dedicated to growing of the paddy hence making paddy growing the main economic activity in the region mainly from selling of the rice casual laborers in the fields.

3.11 Assessment of rice production

AREA, YIELD AND PRODUCTION OF RICE (PADDY) IN

THE WORLD

REGION	AREA	YIELD	PRODUCTION
	(Thousand hectares)	Kg/ha	(Thousand metric tons)
AFRICA	4,918	1,714	8,429
N. CENTRAL AMERICA	2,151	4,034	8,678
SOUTH AMERICA	7,545	1,925	14,449
ASIA	129,603	2,800	362,934
EUROPE	375	4,890	1,835
USSR	664	4,217	2,800

Table 2.

From table.2 above it can be deduced that:

- Asia produces 90% of the total paddy produced in the world.
- N. Central America 43.7% of what Africa has under irrigation but produces 103% of what Africa produces.
- Africa should produce 24,065,000 metric tons if it employs post harvest technologies to avoid post harvest losses.

3.1.2 Properties of paddy grains

property	unit
Bulk density	600kg/m^3
mass	2.0 * 10^{-5}
diameter	1.6mm

Table 3

3.2 Assessment of the post-harvest losses

I carried verbal data collection in assessment of the methods of paddy handling right from harvesting to milling, and identified the areas where the losses occur in the assessment I used literature from other sources like (Post-Harvest Biotechnology of Cereals) to identify the key losses areas as indicated in the theoretical frame work and realized that most losses because too much transportation to and from the drying field and storage of wet paddy.

3.2.1 The main post harvest losses incurred are:

- Weight loss (quantity)
- Nutrition loss
- Quality loss
- Loss in viability of the seed.
- Damage

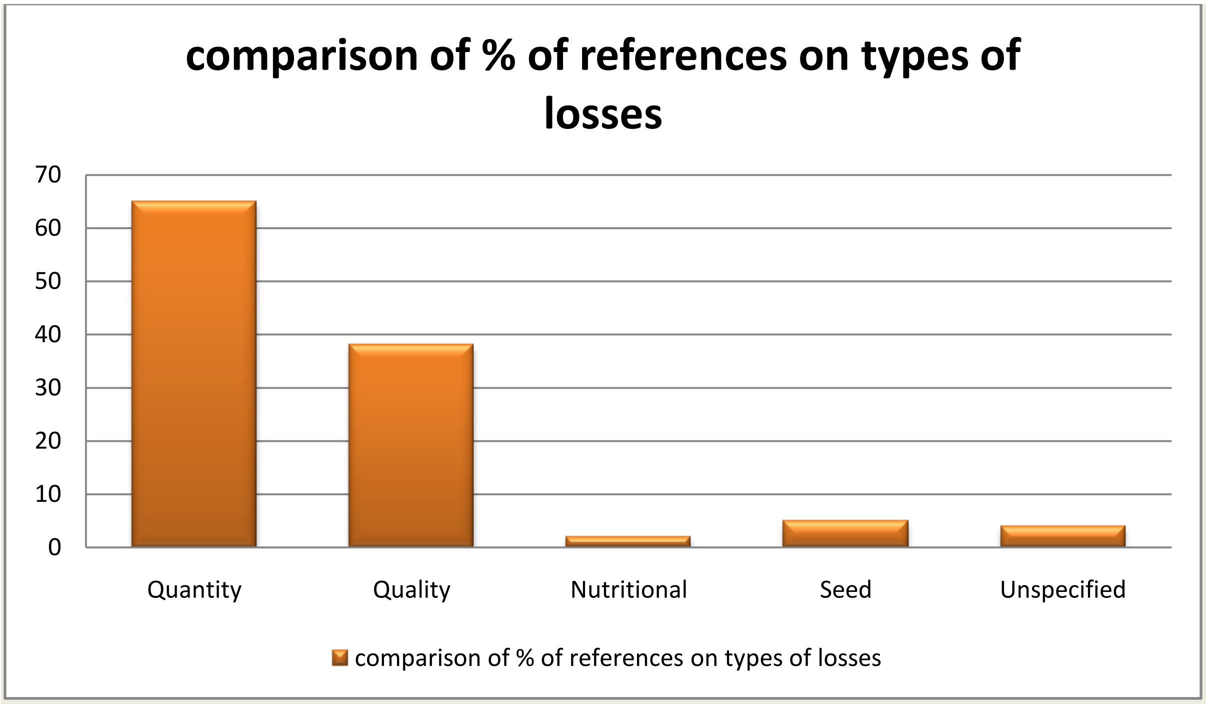


table.4

3.2.2 Identification of the areas of the losses

Losses occur at various post-harvest stages. The magnitude of the loss depends upon the stage, method of handling.

A. Harvesting

Shading or shattering of the paddy grains during harvesting is a common feature of grain loss, especially where the crop is harvested late after maturity. The presence of wind during harvesting increases shattering loss. The paddy is also subject to losses during field drying of stocks due to birds preying on them.

B. Threshing

- Threshing is done by traditional methods. The dried produce is either beaten against stone or wooden bars or trampled bullock feet, carts. The losses occur due to spillage and mixing of grains with soil, incomplete threshing, attach by birds or rodents, and physical damage to the grains.

C. Drying

When the harvested ears or threshed grains are spread on yards for sun-drying part is eaten by birds, rodents, insects and pests. Inadequate and uneven drying leads to fungal invasion. Part of the grain is also lost due to mixing with the soil if the yard is not a hard plain surface. The use of mechanical driers eliminates the problems. However the drying of paddy in mechanical driers needs proper care to avoid loss in process properties.

D. Transportation

Losses occurs during transportation of the paddy from fields to threshing yard, from threshing yard to the place of storage, from storage to mills, from mills to market, and from market to wholesalers, public distribution agencies and other stockiest. The extent of the losses depends on the type of transport systems and the facility used to transport the grains and climatic conditions prevailing at the time of actual transit. Losses during transportation are mainly due to spillage. However, if the grains are caught in bad weather such as rain or frost during transit, it leads to subsequent spoilage due to infection by micro-organisms

3.3 Analysis of the existing types of drying systems

On the assessment of the various drying systems in the world there advantages and disadvantages in order to establish a suitable one which would dry all the seasonal produce with much more efficiency.

3.3.1 Methods of paddy drying

1. Sun drying

   Sun drying is a very useful method for smaller quantities of paddy if a favorable climate prevails. During sun drying, the moisture content may be reduced to 17% with stirring at half hour intervals followed by 2 to 3 hour tempering under cover and final dryingto about 14% moisture, particularly for wet season paddy. Under such situations microbial spoilage is possible before the drying is completed

2. Chemical drying

   Certain chemicals have been used to reduce the moisture content of high-moisture paddy chemical including acetic acid propionic acid, bleaching powder, mercury chloride, copper sulphate, urea, ferrous sulphate, and sodium chloride have been tested other ongoing tests like the use of super absorbent polymer.

3. Mechanical drying

   Mechanical driers based on medium or high-temperature forced-air drying such as: bin dryers, batch dryers, or continuous air flow dryers, are commonly used for paddy drying. Mechanical dryers especially the batchtype farm dryers or the in-bin dryers, can be used for small quantity of paddy.The existing mechanical driers are:

Low-temperature drying

- On- the-floor Driers
- In-bin Driers
- Tunnel Drying

Medium temperature Driers

- Tray Drier
- Radial-Flow Driers
- Multi-duct Ventilated Flow Driers
- Sack Drier

3.4 Designing the dryer

I calculated the size of the based on amount of paddy it needed to handle within its specified time to encourage from harvest to milling without inconveniencing the farmers to late harvest. The design was based on the idea from (The Alvan Blanche Dev., Co. Ltd., Heyworth, Amesbury, U. K.)

3.4.1 Sizing of the dryer

<u>Elevated view of the bed both the drying & the cooling chamber</u>.

The bed would be made of a stainless steel mesh whose diameter would have a diameter of less than 1.4mm given that the diameter of the grain is 1.6mm.

Its dimension would be as shown.

6m

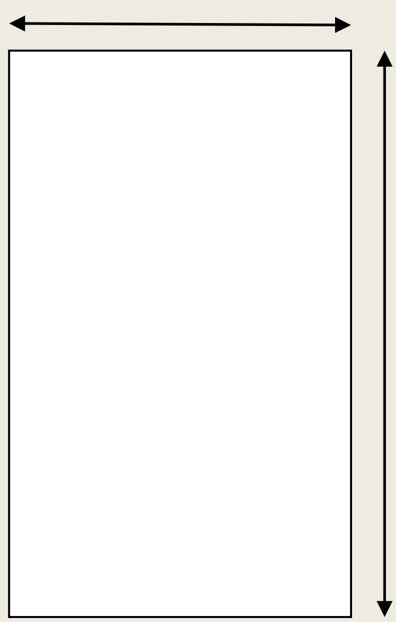


Fig a.

10m

AREA= L * W

(10 * 6)= $60M^2$

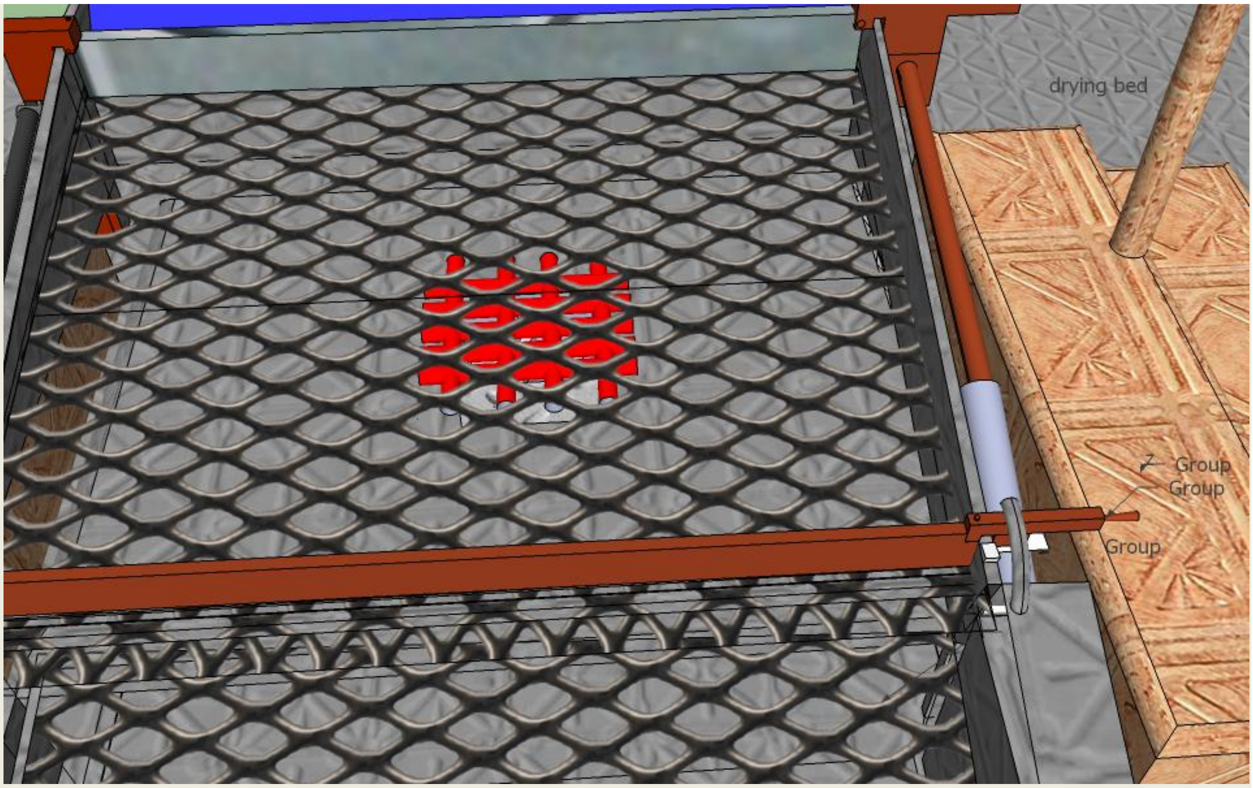
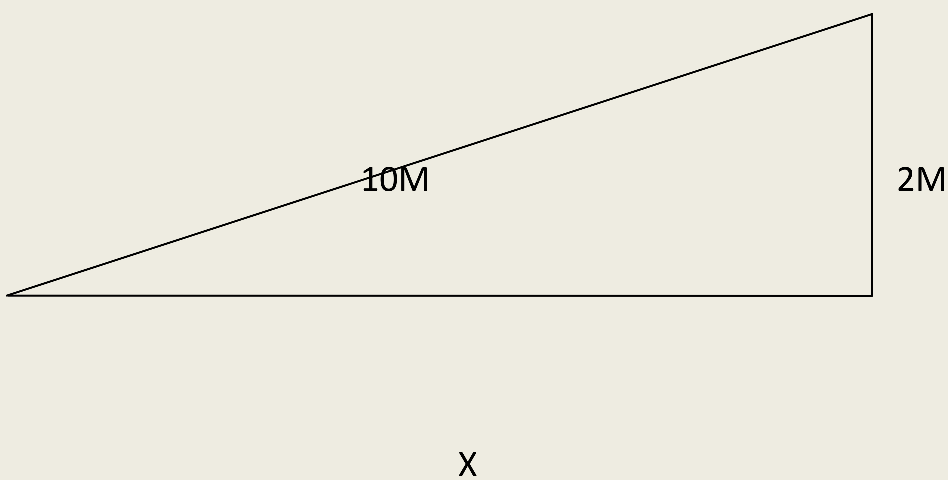


Fig. 1

Fig .b

Cross-sectional view of both the drying and cooling chamber.



PYTHAGORAS THEOREM

$a^2 + b^2 = c^2$

$10^2 - 2^2 = 9.79m \approx 9.8m$

Hence,

Volume of the chamber is given by:

$A = \frac{1}{2} * L * W * H$

$= 9.8 * 6 * 2/2$

$=58.8m^3$

Calculation of bed depth (d)

Given,

Density of paddy is 600kg/m^3, mass accommodated at a given time is 2600kg

Volume (v) = mass/ density

V = 2600/600

=4.33M^3

Hence,

Depth of paddy (t) =volume /area

= 4.33/60m^2

T =7.2cm (assume d is twice t)

D = <u>14.4cm</u>

3.4.2 Determining drying rate

- Yield per hectare= 1714kg (according to table 1 above)
- Ahero irrigation scheme has estimate 5000ha according to NIB and the plots are divided into 20 estates (A, B,C,D………T) to enable efficient service provision.
- This are arranged in a way that there is an interval of 30day between harvesting from one estate to the next one in that series.
- For the machine to work efficiently without failure during harvesting season it has to dry at the rate of 2.6 tones/hour

Yield/ha = 1714kg,

Area of land under irrigation = 5000 ha

Yield per harvest per estate = $\frac{171\text{愁}\times 5000}{20}$ = 428.5tonnes

Assuming that the system is working 8hours on a daily basis, it will take approximately

$\frac{428.5}{2.6\times 8}$= $20\frac{1}{4}$days

This leaves the extra nine days for servicing and mentainance of the dryer..

% moisture content of paddy on harvesting = 22%-20%

(22+20)/2= 21%wb on average

3.5 Calculation of the required conditions

The required temperature conditions I acquired the temperature used in batch dryers which used the same retention time of 1 hour (An International Journal: Drying Technology, 1987).

In the fan selection procedure I used (Hudson Corporation Axial fan selection procedure) by determining the velocity of air required and the quantity of air to be delivered.

The cylindrical plate fin heat exchanger was selected as per the pre-determined required drying temperature and its efficiency and effectiveness calculated as per the mathematical equations of fin calculations and its area calculations were as shown in the analysis.

Assumptions

I. Drying of paddy in bulk in such a dryer can be represented by the drying of a single spherical particle.

II. The working conditions of the dryer are assumed to be same as conditions in a column dryer at 62^0c.

3.5.1 Modeling of humidity conditions in the chamber

The humidity conditions inside the chamber I used (Becker et. Al, 1978) mathematical equation to model. I used basic distance and time equations to the velocity of the grains along the drying bed.

The variation of moisture content of paddy is experimentally studied in a column dryer. It is seen that the drying of paddy in bulk in such a dryer can be represented by the drying of a single spherical particle.

The drying of a spherical particle is characterized (Becker et. Al. 1978) by

$$\frac{dm}{dt} = \frac{D}{r2} * \frac{d}{dr} \left(r^2 \frac{dm}{dr} \right) \text{.......................................(1)}$$

Where, m is the moisture content at radial distance r within the particle and D is the diffusion coefficient of grain moisture and t is time. The solution of equation (1) with the boundary conditions

- $M(r, o) = m_{in}$ (initial m.c)
- $M(r_p, t) = m_{eq}$ (equilibrium m.c)

As shown by (Becker et. Al. 1978) to be given by

$$\frac{m - m_{eq}}{m_{in} - m_{eq}} = \frac{6}{\pi^2} \Sigma \frac{1}{n^2} \exp\left(\frac{-n^2 \pi^2 x^2}{9}\right) \text{...(2)}$$

Where,

$$x = \frac{A}{V}(D\,t)^{1/2}$$

and A is the surface area of a single particle, V is the volume of a single particle and r_p is the particle radius.

The relevant expressions for D and m_{eq} for paddy are (Viswanathan 1983, Boyce 1965)

$$D = 1.01 \times 10^8 \exp\left(\frac{-14160}{273 + \theta}\right) \qquad (3)$$

And

$$M_{eq} = 0.06015 + (2172.8\, W^{1/2} / (T + 17.8)^2) \qquad (4)$$

Where

θ is the grain temperature, T is the drying air temperature and W is the humidity ratio of drying air. Equations (3) and (4) are based on experiments in spouted bed dryer.

The values of m_{eq} 14% according to Table .3

Temperature of the drying air is established i.e I used the drying temperature used in column dryers as per (*The drying technology journal, volume 5.*) which was established as 62^0c

Hence,

The humidity ratio in the drying chamber can be established using equation (4) above

$$0.14 = 0.06015 + \frac{2172.8\sqrt{W}}{(T + 17.8)2}$$

The chamber humidity ratio is found to be 0.05 =5%

Because the humidity ratio of the area varies between 55-60% it is therefore a recommendation that the chamber should be sealed completely during the process.

Theoretical data of prospected drying operations of the machine within the stipulated time of 75minutes. Its then very factual that 14% moisture content would be achieved in an hours time.

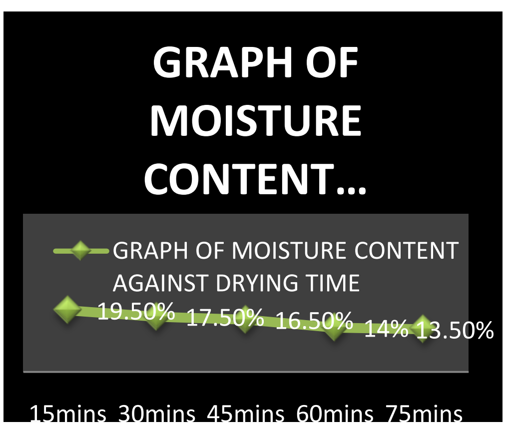


Table 5

the graph above was obtained from performance of a column dryer operating at a temperature of 62^{o}c.

4.0 RESULTS AND ANALYSIS

4.1APPROXIMATION OF THE GRAIN VELOCITY

Static coefficient of friction of a polished stainless-steel= 0.24

Mass of a grain of paddy is = $2.0 * 10^{-5}$

Hence,

F=Mgsinα - μRsinα

ASSUMPTIONS:

- *The 2.6 tones were being fed into the hopper on a quarterly basis an interval of 15mins.*
- *There is inter-particle attraction hence the grains move as a mass.*

The first 15mins there was $\underline{2.6 \times 10^3}$ = 2600KG

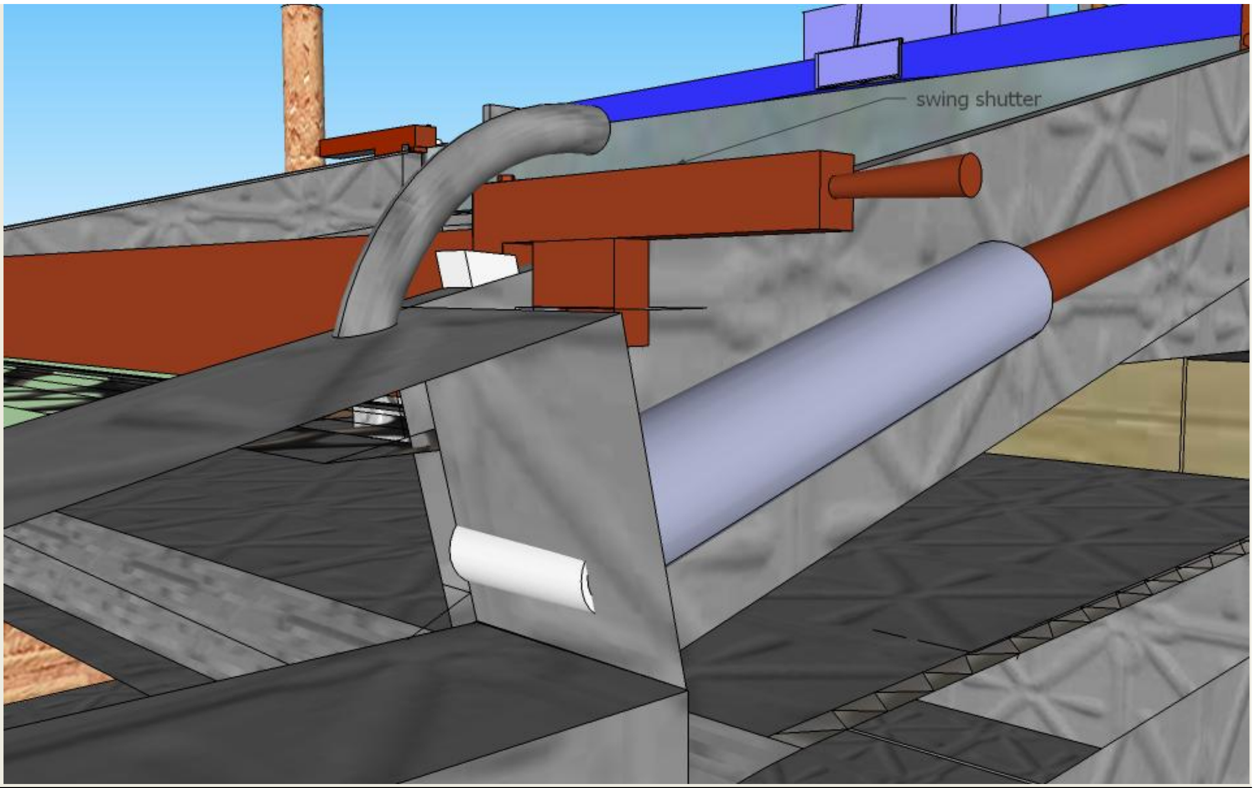
F = (2600 * 9.81 *0.2) – (0.24 * 2600 * 0.2) =

F = 5101.2- 124.8

=<u>4976.4N</u>

- $F = 1/2\ MV^2 = 4976.4N$
- $0.5 * 2600 * V^2 = 1244.1 = 1.957m/s$
- Time the grain uses to travel to the start of the cooling bed.
- Time (t) = s/v
- 10m/1.957m/s
- = 5.11secs

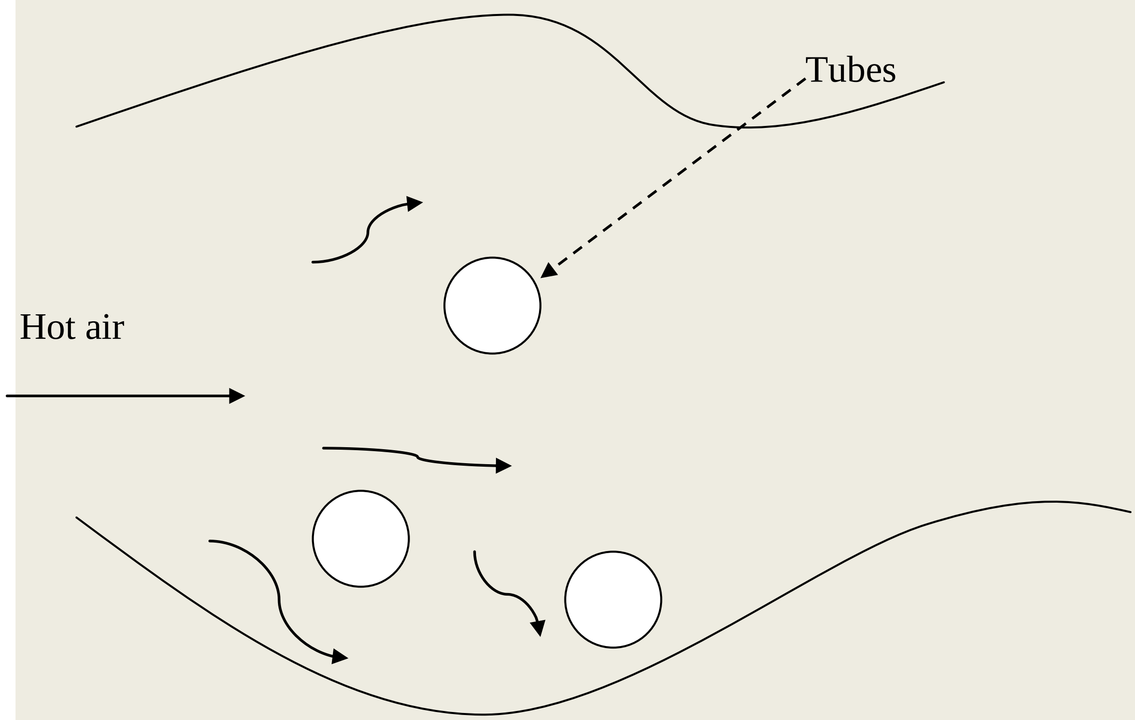
Fig. 2



The lower end swing shutter would perform the function of ensuring the grains take the required amount of time on the drying bed. Would be operated manually and only after the specified time.

ANALYSIS FORCED CONVECTION SYSTEM OF THE HEAT CONVEYED BY THE PLATE-FIN THROUGH THE FAN IN THE CHAMBER

Forced convection is the heat transfer by convection on external edges such as a fan.



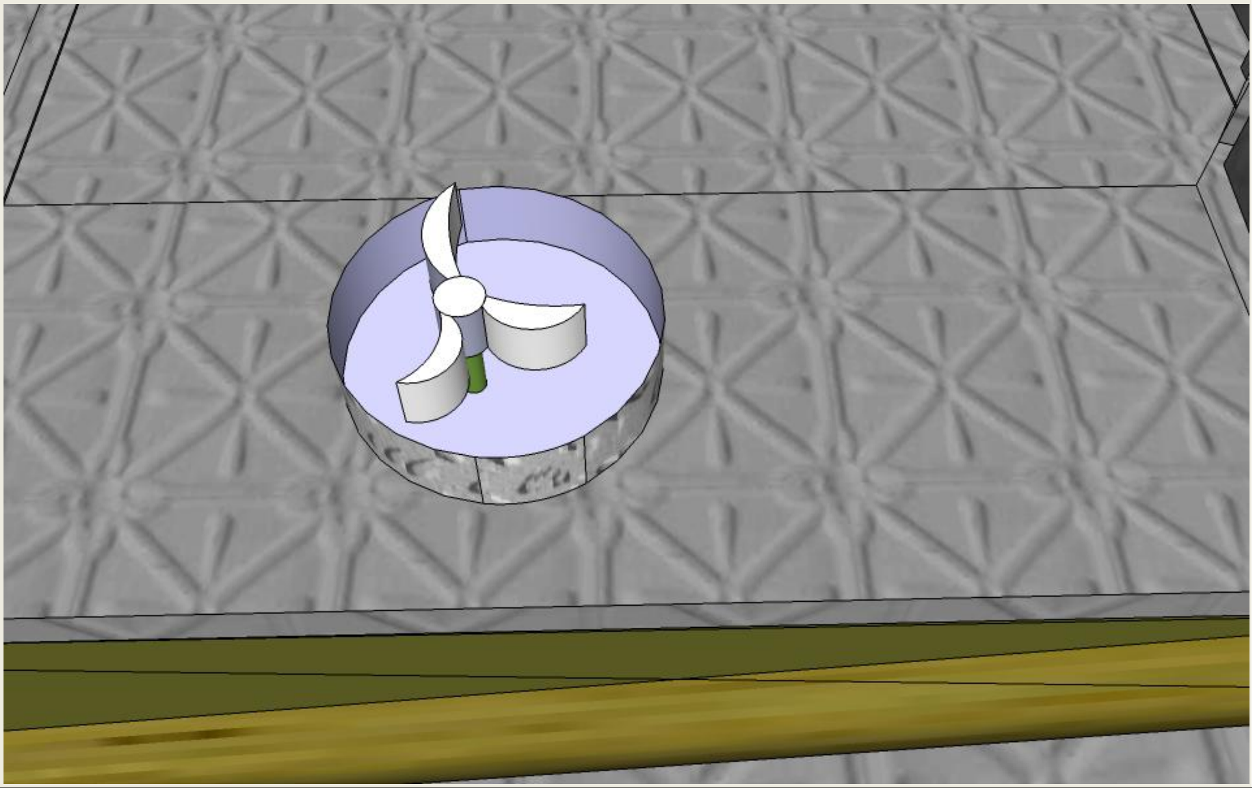
The air molecules assume a circular motion due to there bombardment hence creating a lot of turbulence.

Properties of air at 335K are shown in the table below:

Prundelts no.	0.732
Air density	1.114kg/m^3
Specific heat capacity	929.1 j/kgk
Thermal conductivity constant (k)	0.02974w/mK
Convective heat transfer coeff. (h)	50 – 250 w/m^{2}K
Reynolds no.	2100
Coefficient of viscousity (	2.34kg/ms
Terminal velocity of paddy	7.32m/s

Table 6.

Fig. 3



FAN PERFORMANCE CALCULATION

Drying fan

Fan selection procedure

Define operating conditions:

- ASP (actual static pressure) =20mm-h_2o
- Fan diameter = 3m
- Fan ring diameter =0.3m

Net Fan Area(NFA)

Where,

Fan area = 3.142 * 1.5^2

$7.07m^2$

Fan ring area

= 3.142 * 0.15^2

= $0.070695m^2$

$7.07 – 0.07069 = 6.999m^2$

- Area of the blades is $=0.8235m^2$ (Blade type: select Tuflite II®, designated by "H" after fan diameter)

NFA = $6.999 - 0.61857 = 6.1755\ M^2$

ACFM (Actual Cubic Feet per Minute)/ACMS(Actual cubic meter per second)

- Given that the terminal velocity of the grains is 7.32m/s
- And area of the drying bed is $60m^2$

Where by,

Q = (VELOCITY × AREA) + VAN KARMANS Q

Q is therefore given by:

Velocity × area

$7.32 \times 60 = 439.2m^3/s$

<u>VAN KARMANS Q</u>

Applying (van Karman street vortex equation) of high velocity turbulent flow

$C_D = \frac{FD/A}{ñ\,V\infty/2}$

Where,

$C_D = 5.67(Re_D)^{-0.025}$, $Re_D = 2100$

$C_D = 5.67(2100)^{-0.025}$

$C_D = 4.68$

But drag force = 0

Hence,

V= 0

439.2m^3/s +0

Q = 439.2m^3/s

Fan velocity can therefore be determined by,

V = Q/ NFA

439.2/6.1755

=71.12m/s

The diameter about ten feet which is just about 15HP according to the table BHP ranges obtained from (Hudson Corporation) as shown below:

6-10 ft diameter	7.5-15HP
12ft	20-30HP
14ft	30-60HP
16-20 ft	50-100HP
24-30	100-250HP
36-40ft	150-300HP

Power consumed by the fan=

$15 \times 0.746 = 11.19$kw

In order to find the efficiency of fan designed above the following are obtained first:

Total pressure(TP) = static pressure(SP) + velocity pressure(VP)

Where,

SP = 20mm-$h_2o \times 9.806$

= 196.12pa

$$VP = \frac{FORCE(F)}{NFA}$$

But,

F=POWER/VELOCITY

F = 11190/71.12

= 157.34N

Hence,

VP= 157.34/6.1775

25.46pa

Since,

TP= 25.46+196.12

=221.59pa

$$Eff_{total} = \frac{ACMS * TP}{6356 * BHP}$$

= 78.9%

GRAINS COOLING FAN

Because the grain cooling fan is basically doing the reverse of what the grain drying fan does i.e.

grain temperature on entry is 29^0c and is heated to 61^0c which is nearly the drying temperature, while the cooling fan has to reduce the temperature upto nearly the room temperature.

Grain heating and cooling curves of temperature against time

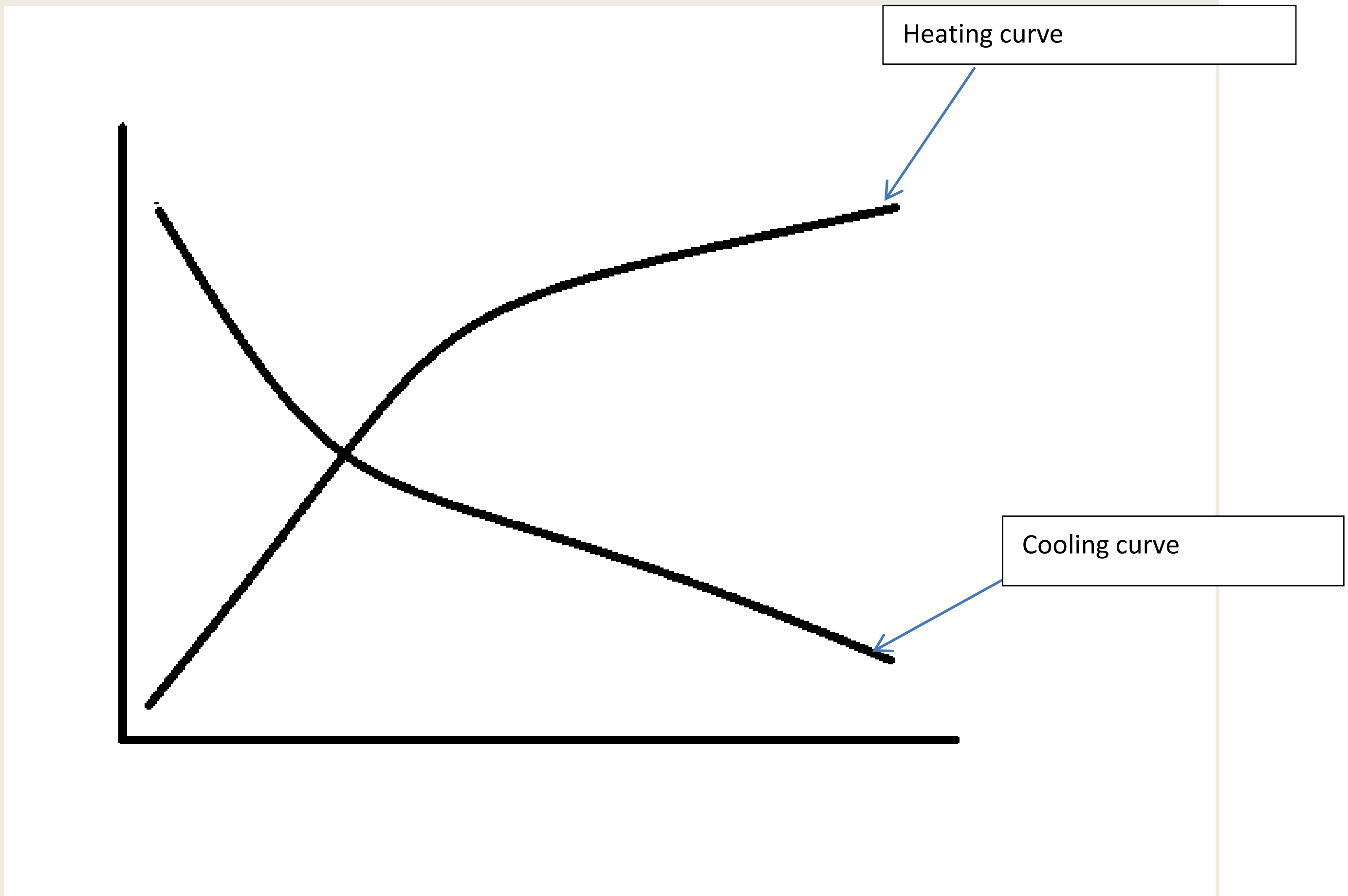


Table 7

QUANTITY OF HEAT REQUIREMENT AT THE BED LEVEL

Quantity of heat gained by the grains while drying is given by:

- Q = (ρ* C_p * $\frac{VÄ餐}{Ät}$)
- Where, ($\frac{d2T}{dx2}$+$\frac{d2T}{dy2}$+$\frac{d2T}{dz2}$)+q =(ρ* C_p * $\frac{VÄT}{Ät}$)
- =given that ρ = 1.114kg/$m^3$for air @ 335k
- t = 3600secs(1Hour),
- ΔT = (62-29)+ 273K =306K,
- V = 71.12m/s,
- C_P= 929.1j/kg k for air @ 335k
- 929.1 * 1.114 * 71.12* $\frac{306}{3600}$

- q= 6,256.89 w/m^2

Q =6256.9*60m^2 = 375,414 Watts

- This is therefore quantity of heat required to dry the 2.6 tons at a temperature of 335k.

Using plate-fin heat exchangers

The heat inside the chamber would be generated using plate fins which would be located just above the fan; the type of plates used would be of a cylindrical shape and should have a surface area of nearly 7.5m^2 i.e should cover the fan area and other properties would be as follows: h would be determined given that Q has already been determined.

No. of plates = 200

Diameter = 0.186m (determined using ∏r^2)

Length = 1.38m

A =7.5m^2

Q_{fin} = 375414watts

q_{fin} =hp(T - Tf) ϕ

Where,

$$\Phi = \frac{e^{ml} - e^{-ml}}{e^{ml} + e^{-ml}}$$

Given that effectiveness ranges between 35-37 of fins range from

Fin effectiveness (ε)

Fin effectiveness is the ratio of heat transfer from the fin to the heat transfer if the fin wasn't existing. In other words, this quantity tells us how much extra heat is being transferred by the fin.

The desire is to have this ration as large as possible while keeping the additional cost of adding the fins as low as possible.

$E = Q_{fin}/Q_{without\ fin}$

Q_{fin} = 375414watts

Assumption: fin effectiveness for a good working fin is 37.

Hence,

$37 = 375414/q_{wthout}$

$Q_{wthout} = 10,146.3 w/m^2$

$Q_{wthout} = h A_c (T-T_f)$

A_c = fin cross-sectional area

T_f = surface temperature 29^0c

T = temperature required 62^0C

h = $40.99 w/m^2K$

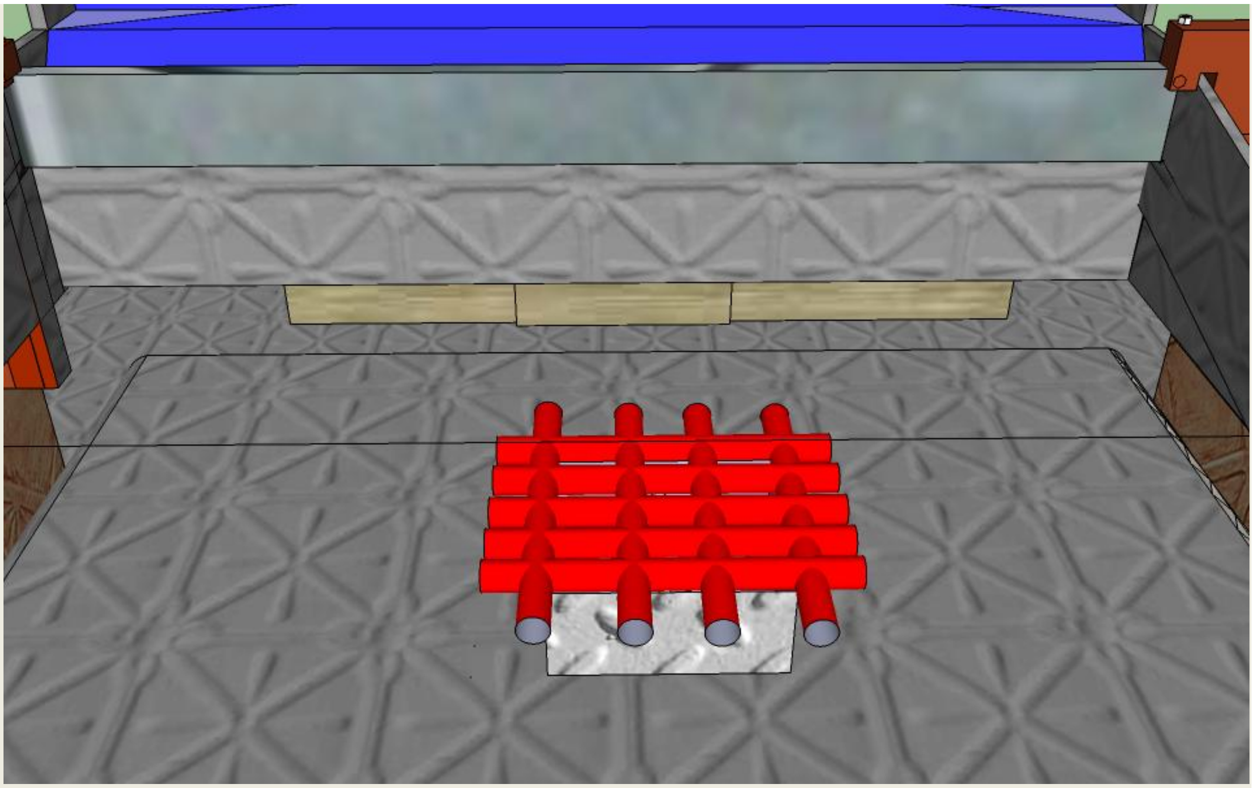


Fig 4

5.0 Discussion

Cascade type paddy dryer doesn't require a lot of effort during the period of drying because it uses gravity to transport the grains along its bed and hence doesn't require a set of pulleys during its operation. Making it less complicated.

Since the velocity of the fan 71.12m/s) was calculated bearing in mind the terminal velocity of the grains (7.2m/s) are the only thing which will be blown away chaffs which have lighter density will be removed in the process while the paddy will be moved in a fluidized manner.

Grains at 14^{o}c with Reynolds number (N =2100) in the range of turbulent flow for them to flow under gravity is required, therefore to encounter this incorporation of a swinging shutter which is adjusted along the bed using the hydraulics on both sides of the bed.

bed can be successfully without the paddy being blown away designed using all the stated The dryer parameters used in the design in the analysis and the theoretical framework.

These can be proven theoretically:

Momentum = mass * velocity

Momentum of the drying air:

71.12m/s * 1.114kg/m^3 * 58.8

= 4661.9kgm/s * 0.2 *(air is heating the bed at an angle of 20^{0}c)*

=<u>932.38kgm/s</u>

Momentum of the grain on the bed:

2600kg * 1.957m/s

<u>1553.9kgm/s >932.38kgm/s.</u>

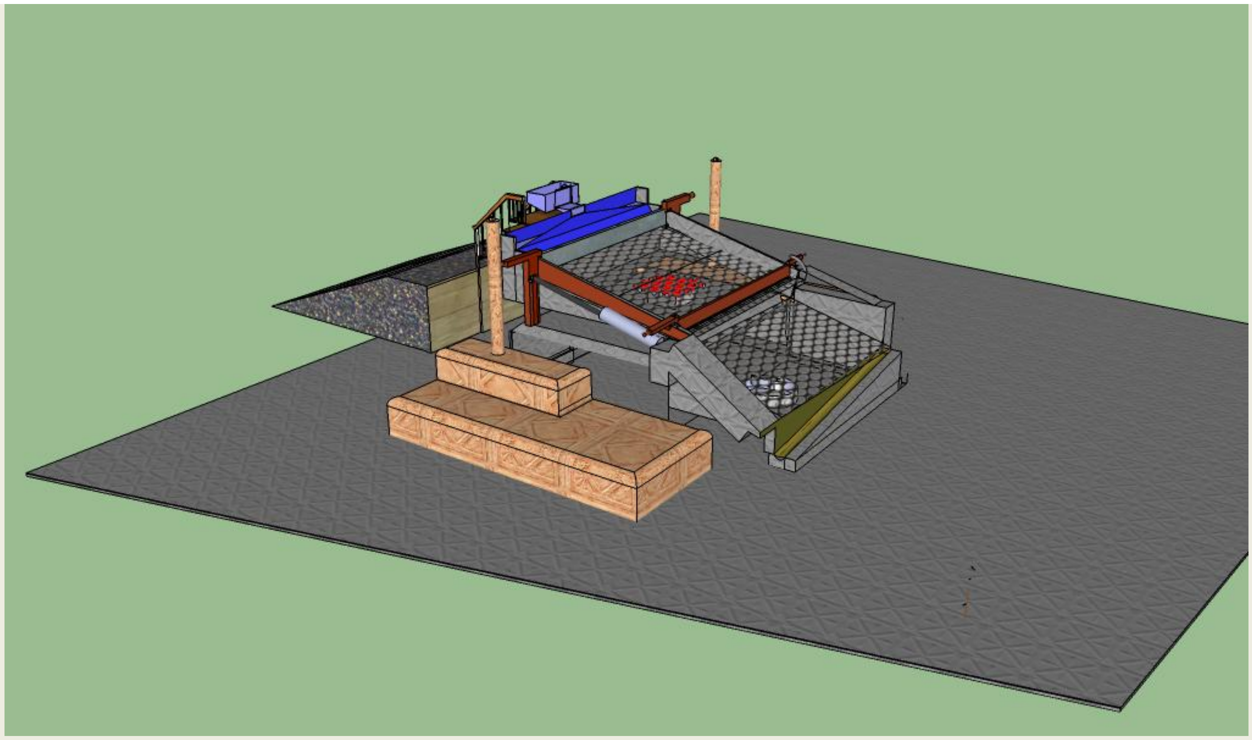


Fig. 5

6.0 CONCLUSION

Post harvest losses can be reduced by upto 5% if the cascade type paddy dryer is developed the mathematical calculations have proven that the system is legitimate and my research has shown all the areas where the losses occur

Among the type of losses, more attention has been paid to the quantitative losses in weight and market quality. An examination of the available field information on the causes of losses shows that overriding importance has been attached to insect infestation vertebrate pest has been on losses of paddy due to other agents such as rodents' micro organisms, and chemical reactions.

The post-harvest conservation is an important and hitherto neglected dimension. If these losses are reduced through improved post-harvest biotechnology Cascade type paddy dryer, the world food supply can be increased by 30 to 40% without cultivating any additional acres of land or incurring additional expenditure on seeds, fertilizers, irrigation, and plant protection measures to grow the crops.

Heavy losses in paddy and milled rice are reported during post-harvest handling in Asia and Africa. The harvesting, threshing, drying and processing of paddy need special care as compared to other cereals.

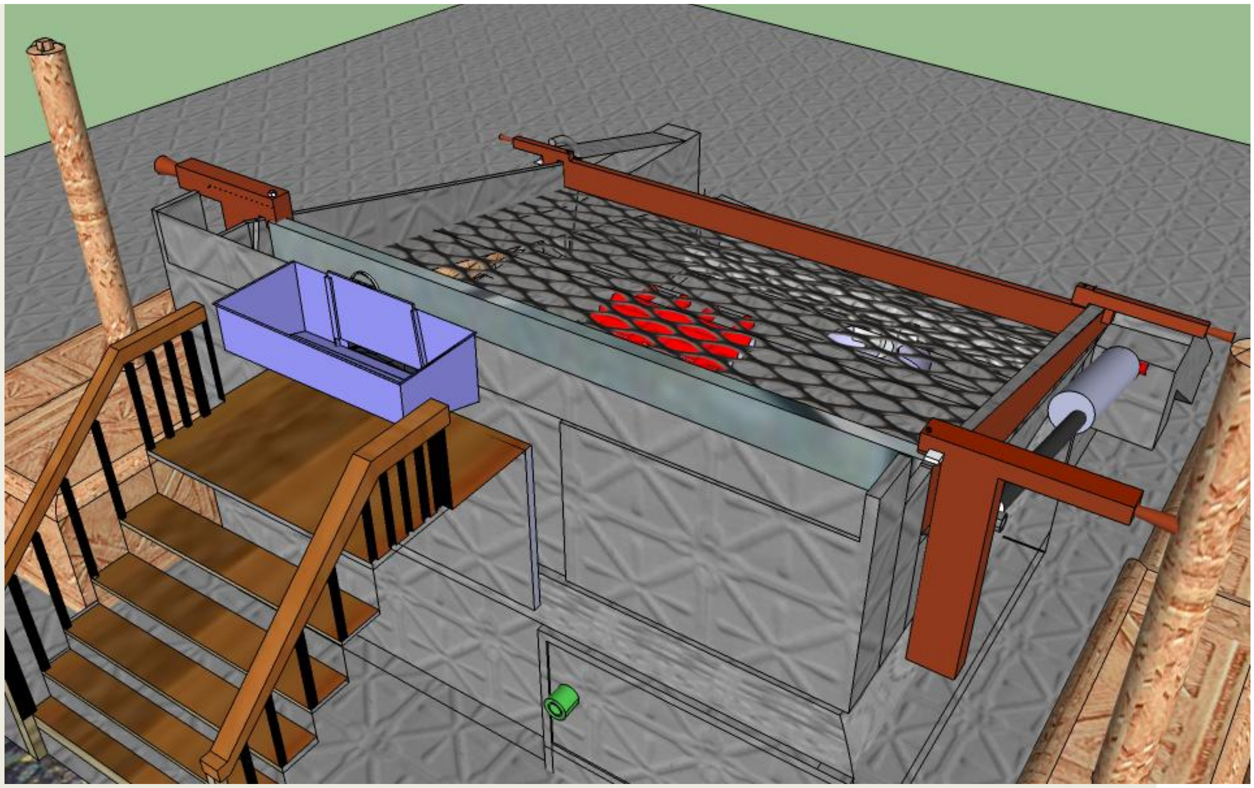


Fig. 6 rear view

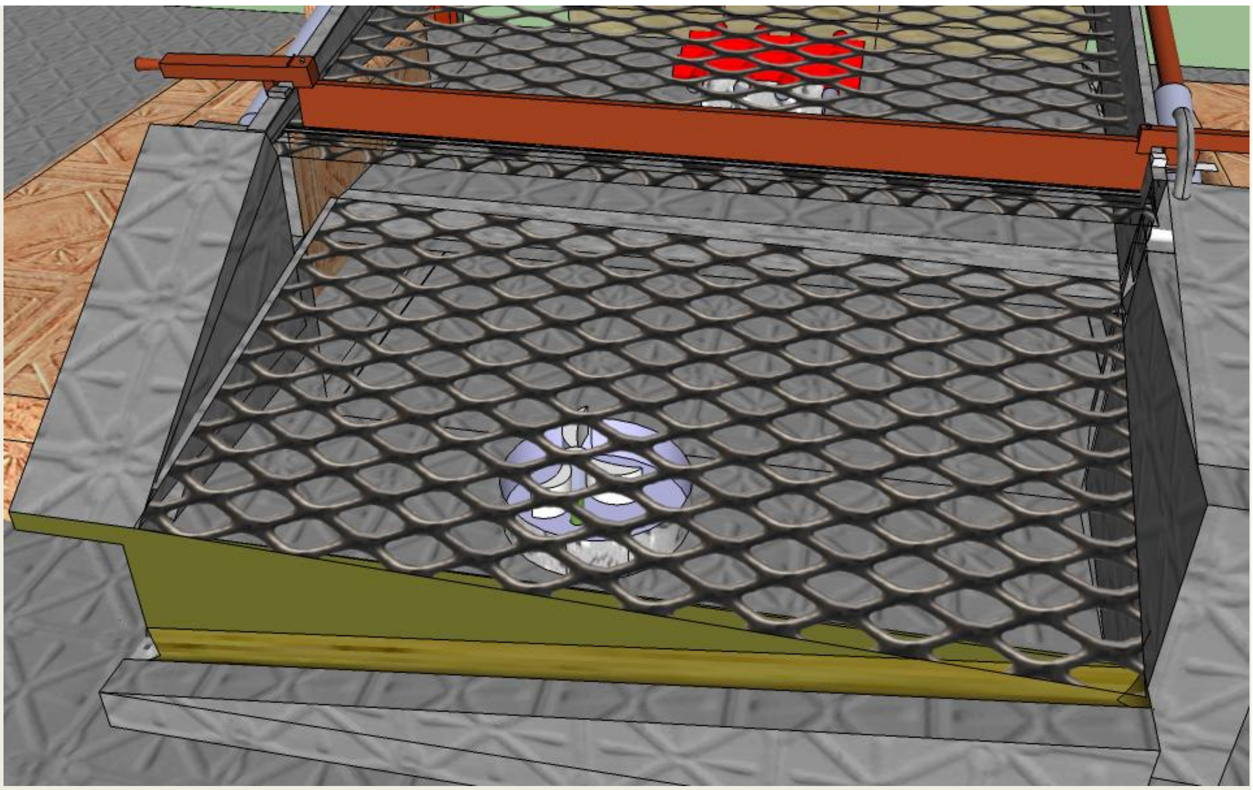


Fig. 7front view

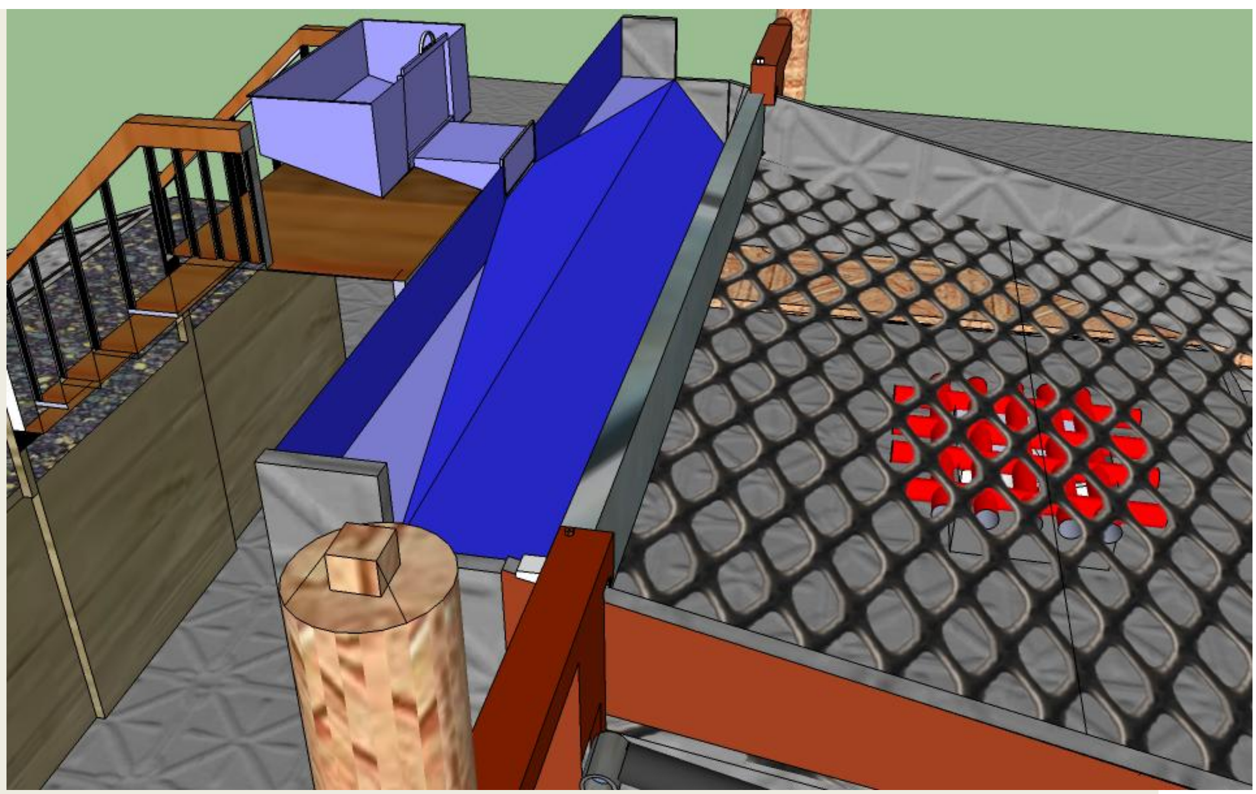


Fig 8 side view

7.0 Recommendation

Due to the high losses during threshing which can be up to 6% the farmers should be cautious to adopt IRRI-designed axial flow threshers, or IRRI-designed portable thresher.

An alternative source of heat exchanger like: cross-flow, counter-flow, or even triangular and rectangular plate fins which have a much higher efficiency can be considered for better performance.

The grains are still bound to losses even after milling hence the farmers can look for customers as early as the harvesting time as opposed to when customers were only interested in dry grains which took a longer time to dry after harvest.

A more efficient tapering method can still be developed, in place of the shock moving swing shutters.

Recommendations include harvesting at about 20% moisture content, use of portable mechanical threshers, construction of cascade type paddy dryer which operates at the rate of 2.6tonnes per hour simple bulk storage such as metal bins at farm level or village level for storage in the developing countries. Installation of mini modern rice mills in rural areas would greatly help to reduce milling losses. The processing of bran for food purposes is important to improve food availability in the developing countries.

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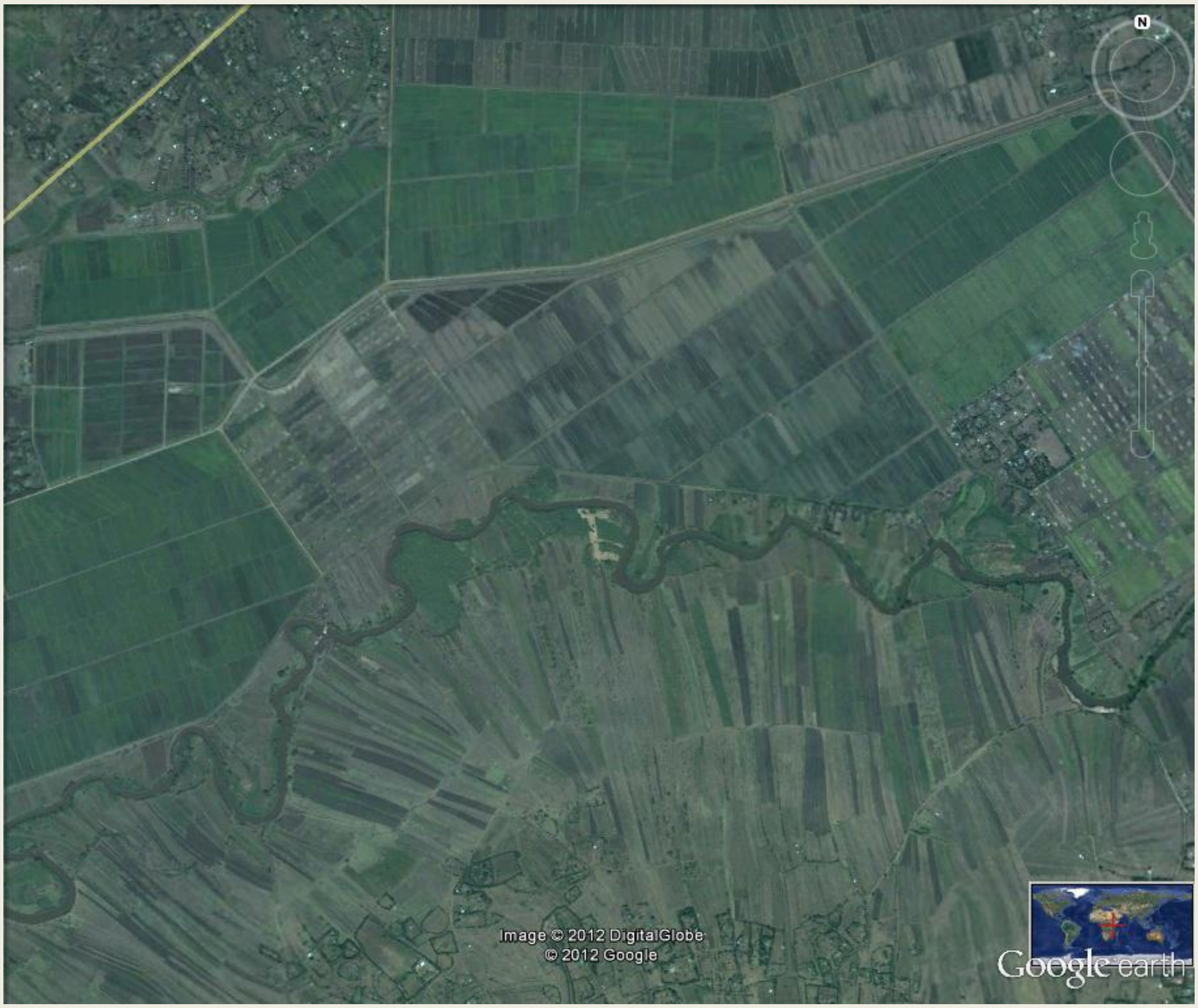
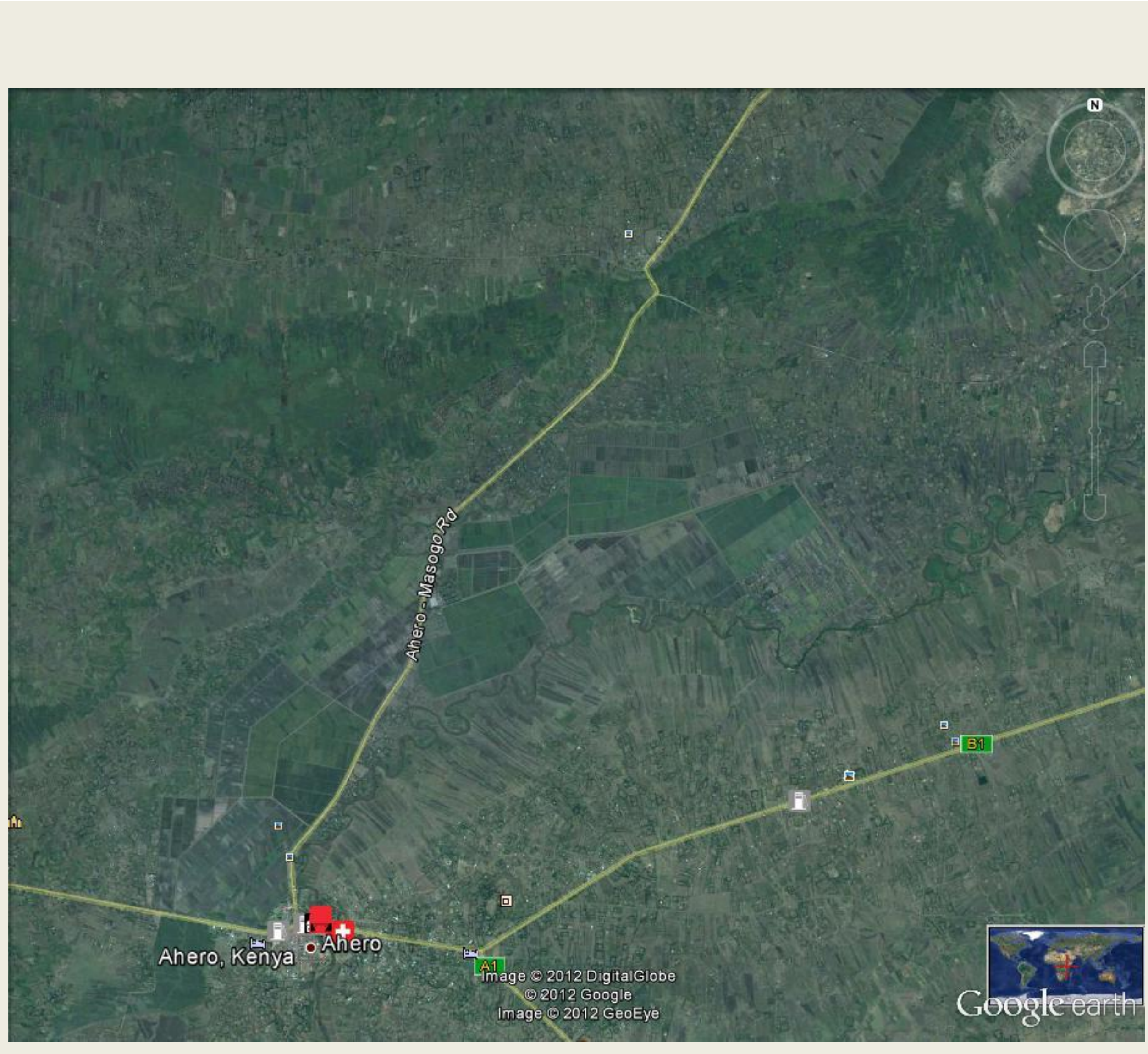
APPENDIX 1.




Ahero-Masogo Rd
B1
Ahero, Kenya
Ahero
A1
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APPENDIX 2

APPENDIX 3

1. Typically for cooling towers or ACHEs, tip speed will be 14,000 FPM maximum.

2. Typical blade quantities per fan are:
up to 14 ft dia. 4 blades
16 - 20 ft 6 blades
24 - 30 ft 8 blades
36 - 40 ft 8 blades

• TIP SPEED

I-P: ft/min

metric: m/s

SI: m/s

• VIBRATION AMPLITUDE

I-P: mils (1/1000 inches)

metric: microns (1/1000 mm)

SI: microns (1/1000 mm)

• VIBRATION FREQUENCY

I-P cycles per minute (CPM)

cycles per second (Hz)

metric: cycles per second (Hz)

SI: cycles per second (Hz)

• SOUND POWER LEVEL

I-P: PWL dB (decibels)

metric: Lw dB (decibels)

SI: Lw dB (decibels)

• SOUND PRESSURE LEVEL

I-P: SPL dB (decibels)

metric: Lp dB (decibels)

SI: Lp dB (decibels

PRESSURE

25.40 * in.-H2O = mm- H2O

249.08 * in.- H2O = Pa

9.806 * mm-H2O = Pa

Pascal (Pa) = N/m2

• VOLUME

35.314 * m3 = ft3

0.02832 * ft3 = m3

• DENSITY

Standard density = 0.075 lb/ft3

16.018 463 * lb/ft3 = kg/m3

Standard density = 1.201 kg/m3

• LENGTH

25.4 * inch = mm

3.281 * m = ft

1000 * mm = micron

0.3048 * foot = m

• TEMPERATURE

(oC * 1.8) + 32 = oF

(oF - 32) / 1.8 =

=

oC

• POWER

0.746 * HP = kW

APPENDIX 4

quantity	Common symbol	unit	symbol	derivation
Length	A, b, c	meters	m	SI-base unit
Area	A	square meter	m^2	
Volume	V	cubic meters	m^3	
Mass	m	kilogrmme	kg	SI-unit base
Density	ρ	kilogramme /meter cubic	kg/m^3	
Force	F	newton	N	IN = $1kgm/s^2$
Weight force	W	newton	N	
Time	t	seconds	s	
Velocity	v	meter per second	m/s	
acceleration	a	meter per second squared	m/s2	
(frequency per cycle)	f	hertz	Hz	1Hz = 1c/s
pressure	P.F	Newton/sq. meter	N/m^2	IMN/m^2 $=IN/mm^2$
quantity of heat	Q	Joules	J	