ISSN: 5224 – 548X
Volume 9, Number 1, 2023
International Journal of Innovations in Engineering Studies

DESIGN AND CONSTRUCTION OF CORN THRESHER MACHINE USING LOCALLY SOURCED MATERIALS

Ikwuebene Benjamin Chukwutem.
Department of Mechanical Engineering,
Delta State Polytechnic Ogwashi Uku, Delta State Nigeria

Email: chuksejiro@yahoo.com.

ABSTRACT

Corn is one of the most important crops and it has a source of a large number of industrial products besides its use as human food and animal feed. Every part of Corn has economic value as the grain, leaves, main crop stalk, tassel and cob can all be used to produce a large variety of food and non-food products. After harvesting with sickle and plucking of cob manually, dehusking of cob is done by hand to remove its outer sheath and further grain is obtained by threshing and shelling the cob traditionally, i.e. by beating the dehusked cobs with sticks or with fingers or sickle, etc. To overcome this problem of removing its outer sheath and dehusking the cobs this machine was developed. The machine basically compromises of separate shelling chamber, threshing chamber, collecting tray and motor (1.0HP). The arrangement of these parts is connected by belt and pulley mechanism. The weight was only 95 Kg. After testing the machine, the production rate for threshing operation was 300 kg/hr and for shelling 300 kg/hr. At last the germination test was carried out for corn seeds threshed by the machine and it were found that time required to grow from seed was about 48 hours. It was discovered that the threshing machine is very efficiency and effective.

Keywords: Threshing, mechanization, efficiency, shelling.

INTRODUCTION

Corn is the most important cereal grain in the world, after wheat and rice, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and, more recently. It is because of the important place of maize that it's handling, processing and preservation within the optimum conditions must be analyzed. The problem of poverty, hunger and malnutrition would be alleviated if there is adequate production of corn, Corn also called maize plays an important dietary role in most parts of Africa, It is grown virtually everywhere, in tropical, subtropical and temperate regions where rain and irrigation is adequate (Messiaen, 1992), Tindall, 1983). The major steps involved in the processing of corn are harvesting, drying, de-husking, shelling, storing, and milling. All these processes may be costly depending on the method, processes and technological involvement to the processing and for the rural farmers to maximize profits on their produce, appropriate technology that suites their needs must be used. Corn processing not only prolongs its useful life but also increases the net profit farmers (users) make from mechanization technologies. It is in this line that one of the most important processing operations done to bring out the quality of corn is shelling. Shelling is basically the removal of the corn kernels from the cob. This separation may be done by hand or machine, it is obtained by threshing through friction or by shaking the products; the difficulty of the process depends on the varieties grown, and on the moisture content as well as the degree of maturity of grain. Corn is considered to be one of the most important staple crops in the world. People in some parts of the world actually consider corn as their survival food. According to the D-Labcorn Sheller writing at the Massachusetts Institute of Technology (Accessed on Oct 4th 2013), corn accounts for 43% of the Latin American diet. Because of the high need of corn grains, it leads to the invention of a wonderful tool called the corn thresher which helps in shelling the corns from the cob as well as makes shelling faster and easier. A threshing machine is a power driven or manually operated agricultural machine used to separate the seed of a harvested plant to the straw and chaff, husk or other residue (Encarta, 2003). Threshing involves detaching of grain from the ear head in corn, or removal of the pod from bean.

Maize processing and preservation must be done to an optimum condition. The major steps involved in the processing of maize are harvesting, drying and dehiscing (Kumar and Gupta, 2003). The process of maize threshing involves the removal of grain from their cobs. The process can be traced as far back as the discovery of the crop as a source of nutrition. Maize is passed in cob or instantly threshed mainly by machines. The need for more efficient methods of maize threshing has over the years resulted in studies carried out on the threshers (Kaul and Egbo,1985). The larger, free – standing threshers are more productive and convenient, but more expensive. They are often with cleaning and separation device for the removal of unwanted material. The relatively large size of maize grain facilitates the use of both cleaning fans for the blowing away of the dust and light particles, and of simple reciprocating sieves for the removal of sand, stripped cob centres and broken or undersized grain. Depending on the type of thresher and on the number of operators employed, the capacity of these machines can be four times larger than that of the smaller rotary threshers.

AIM / OBJECTIVES

The aim of this research is to create a compact system that will be easy to handle and as well as not being complex in the operation, that will help in solving problems encountered in the use of manual way of threshing corn that will help to reduce time spent in threshing corn using locally sourced material

The main objective of this research is to design and construct a corn threshing machine.
Other specific objectives are

- To construct a corn threshing machine that can separate the corn from the cob effectively.
- To design a corn threshing machine that will operate with optimum efficiency
- To help the farmers to reduce stress through the use of corn threshing machine

LITERATURE REVIEW

Conceptual Framework

A threshing machine or a thresher is a piece of farm equipment that threshes grain, that is, it removes the seeds from the stalks and husks. It does so by beating the plant to make the seeds fall out.

Before such machines were developed, threshing was done by hand with flails: such hand threshing was very laborious and time-consuming, taking about one-quarter of agricultural labour by the 18th century Nazzir, W. (2008). Mechanization of this process removed a substantial amount of drudgery from farm labour. Michael Stirling is said to have invented a rotary threshing machine in 1758 which for forty years was used to process all the corn on his farm at Gateside. No published works have yet been found, but his son William made a sworn statement to his minister to this fact. He also gave him the details of his father's death in 1796.

Separate reaper-binders and threshers have largely been replaced by machines that combine all of their functions, that is combine harvesters or combines. However, the simpler machines remain important as appropriate technology in low-capital farming contexts, both in developing countries and in developed countries on small farms that strive for especially high levels of self-sufficiency. For example, pedal-powered threshers are a low-cost option, and some Amish sects use horse-drawn binders and old-style threshers.

Historical Background of Corn Threshing Machine

The first ever corn thresher was invented by Lester E. Denisonat Sayville Middlesex country, connecticus. Today, corn threshers come in wide variety of sizes and types. From the simplest hand-held device to the more complex bigger self-feeding machines powered by steam, corn separation has been successful since then. The technology of food crops production has undergone rapid change in the recent decade to meet the rising demand of food with a corresponding rise in population.

Different forms of farm machinery are being employed in various stages of crops production which improves the quantity of farm produce and its quality. Special agricultural machinery has been developed to replace the primitive method of crops processing after harvesting. The operations carried out after crops are harvested include, cutting the ear heads or cub from the harvested plant, detaching the grain from the ear head, separating the grain from other materials like chaff and pod shell. The agricultural machine used to accomplish the operation of separating the grain from other materials like chaff pod from grain is called a threshing machine (Encarta, 2003).

Corn is the Third largest cereal produced in the world with a trend of rising production in India. The normal area for Corn in India was 77.27 lakh hectares with production about 150.91 lakh tones in the year 2007. Rajasthan has the largest area 10.62 lakh hectares under cultivation among all states with total production of 21 lakh tones. Four method of Corn shelling namely shelling cob grain by hand, octagonal Corn Sheller, hand operated Corn Sheller and beating by stick method were carried for removing Corn kernel from the cob. For ergonomically evaluation ten male agricultural subjects of 25-35 year age group were randomly selected for study. Present traditional method of shelling Corn has proved to be inefficient, laborious, time consuming and low output. The energy expenditure rate was highest for beating by stick method (3.84 kcal/min) and lowest for octagonal Corn Sheller (1.52 kcal/min). Traditionally Corn is threshed by shelling cob grain by hand or beating the cob by stick. At present Corn shelling has been improved by the use of tubular Corn Sheller and hand operated Sheller. The energy expenditure rate was highest for beating by stick method (3.84 kcal/min) and lowest for octagonal Corn Sheller (1.52 kcal/min). Energy expenditure rate for shelling cob grain by hand and octagonal Corn shelling operation could be scaled in "Very light" category of work load. Whereas the hand operated Corn Sheller and beating by stick method could be scaled as in "Light" category of work load. For Corn shelling operations octagonal Corn Sheller and hand operated Corn shelling are superior than shelling cob grain by hand and beating by stick Method.

TYPE OF THRESHING

Manual shelling and threshing:

In many regions of the India corn shelling and threshing is done manually, this method is conventional but productivity and output from that method is low and that's why there is a need to switch to mechanical motorised system for corn shelling and threshing.

Mechanical shelling and threshing:

Mechanical motorised corn Sheller and thresher gives more desirable results than manual conventional method of corn shelling and threshing. It tends to saving of the time and also leads to save money. It is desirable to use low cost cornsheller and thresher for economical work and to increase the productivity.

Main Frame

The total weights carried by the main frame are: weight of the hopper; weight of the threshing chamber; the bearings and pulleys. The two design factors considered in determining the material required for the frame are weight and strength. In this work, angle steel bar of 2 mm thickness is used to give the required rigidity.

Material Design

System Design

The methods used were in three phases, the first phase involved the collection of farmer sheller needs and other problems associated with agricultural operation. The second stage was the design of an appropriate system to meet their needs, and finally to communicate results to the farmers and determine whether their problem was solved. The uniqueness of this design is that it works on a different principle of threshing. The earlier mentioned design by Crawford, & Lee, (2003), worked on the principle of impact force, while this design works on the principle of abrasion; an application of force tangentially on a surface. On the field determination of farmer shelling capacity was determined. Comparison was made on the time take to shell the quantity of corn harvested per farmer and the time taken before deterioration sets in. it was observed also that appropriate technology for storage was not available including pesticides to handle weevil attack. Pesticides were purchased with the help of local administrators, who was told of he need in the community.

Table 1.Design Specifications

S/N	PARTS	MATERIALS	DIMENSION
1	Body casing	Mild steel sheet (1.5mm)	33cm x 56mm
2	Hopper (feeding chute)	Stainless steel sheet (1.5mm)	490mm x 250mm
3	Cob discharge unit	Stainless steel sheet (1.5mm)	440mm x 170mm
4	Grain discharge unit	Stainless steel sheet (1mm)	250mm x 90mm
5	Machine frame	1 ½ inch angle bar	410mm x 510mm x 650mm
6	Bearing	Cast iron	Small size
7	Electric motor	Copper	1.1kw/1410rev/min
8	Pulley (driver)	Mild steel	150mm
9	Pulley (driven)	Aluminum	200cm

Design calculations

The following design parameters are:

1. Permissible Shear Stress (T):-

When the external force acting on the component tend to slide the adjacent planes with respect to each other, the resulting stresses in these planes are called shear stress.

$T = S_{yt}/ F.S.= 0.5 (S_{yt}) / F.S.= 0.5 (380) /1.5 = 126.66\ N/mm^2$.

2. Torsional Moment (M_t) :-

$M_t = 60 \times 10^6 (KW)\ \pi N= 60 \times 10^6 (1.492) /2\pi(710)= 20066.97$ N-mm.

3. Bending Moment:

For Pulley (1),D = 130.

Calculation of P_1 and P_2.

$Mt = (P_1-P_2) \times (D /2)$.

$20066.97 = (P_1-P_2)\times 65$.

$(P_1-P_2) = 308.72$. ……………(1)

$P_1 /P_2 = e^{0.3\pi} = 2.566$. ……………(a)

$P_1 =2.566\times P_2$…………………………………………………(b)

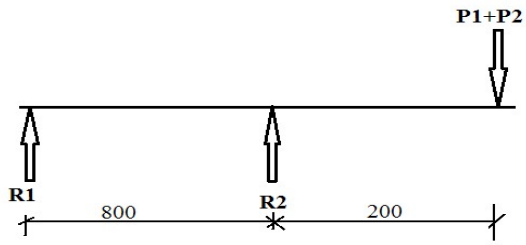
Put value (b) into equation (1).

$2.566P_2 – P_2 = 308.72$

$P_2 = 197.14N$ ……………(c)

From equation (b) and (c).

$P_{1\,=}\ =2.566\times197.14= 505.86$ N



Let, R1+R2 = 703 ....(d)
Taking moment at R1,
R2*800 = 703*1000
∴ R2 = 878.75 N
from equation (d).
R1 = 175.75 N
Now, bending moment is given by,
M_b= (878.5*200) + (175.75 * 1000)
=351.45 N-m
4. Shaft Diameter On Strength Basis:
Transmission shafts are subjected to axial tensile force, bending moment or torsional moment or their combinations.
Most of the transmission shafts are subjected to combined bending and torsional moments.
We know,
$d^3 = \{ [16/(\tau\times\pi)] \times(M_b^2+ T_2^2)^{0.5} \}=\{ [16/(126.66\times\pi)] \times (351450^2 +5830\}$
d = 24.18 ≈25 mm

- Length of belt :-

$$L = 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)}{4C}$$
$$= 2x\ 600 + \frac{\pi(130+63)}{2} + \frac{(130-63)}{4x600}$$

:. L = 1505.03mm
▪Corrected centre distance:-

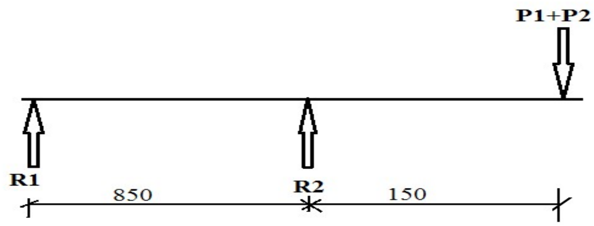
$$L - 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)}{4C}$$
$$:.1600 - 2C + \frac{\pi(130+63)}{2} + \frac{(130-63)}{4C}$$

C = 645mm
:. L = 1505.03mm

Belt, Pulley and Shaft Design for Threshing Operation
Speed (N) = 600 rpm, P = 0.746 KW, S_{yt} = 380N/mm^2,Θ = Angle of wrap, $P_1/P_2 = e^{\mu\theta}$ = 2.566
2. Permissible Shear Stress (τ):-
T = 0.5 (S_{yt})/F.S = 0.5 (380) /1.5. = 126.66 N/mm^2

2. Torsional Moment (M):-
M_t= 60 × 10^6 (KW)/2ΠN= 60 × 10^6 (1.492)/2Π(600)= 23745.92 N-mm.
3. Bending Moment:
For Pulley, D = 125mm.
Calculation of P^1 and P^2.
M_t = (P_1-P_2) × (D /2).
18996 = (P_1-P_2)× 62.5

$(P_1 - P_2) = 303.936$ ……………(1)
$P_1/P_2 = e^{0.24\pi}$
$P_1/P_2 = 2.566$ ……………(a)
$P_1 = 2.566 \times P_2$ ……………..(b)
Put value (b) into equation (1).
$2.125P_2 - P_2 = 368.15$
$P_2 = 194.08$ N ………….(c)
From equation (b) and (c).
$P_1 = 2.566 \times P_2$
$P_1 = 2.566\ (194.08)$
$P_1 = 498.02$N



Let, R1+R2 = 692.1 ……………………(d)
Taking moment at R1,
R2*850 = 692.1*1000
∴ R2 = 814.23N
from equation (d).
R1 = 122.13 N
Now, bending moment is given by,
M_b = (814.23*150) + (122.13 * 1000)
=244.264 N-m
4. Shaft Diameter on Strength Basis:
$d^3 = \{ [16 / (\tau \times \pi)] \times (M_b^2 + T_2^2)^{0.5}\} = \{ [16 / (126.66 \times \pi)] \times (244264.5^2 + 18996^2)^{0.5}\}$
d = 21.44 ≈ 25 mm.

- Length of belt :-

$$L - 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)}{4C}$$

$$\therefore 2C + \frac{\pi(130+63)}{2} + \frac{(130-63)}{4C}$$

L = 1297.23mm
from std. table, L = 1250mm

- Corrected centre distance (C):-

$$L - 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)}{4C}$$

$$1250 - 2C + \frac{\pi(125+63)}{2} + \frac{(125-63)}{4C}$$

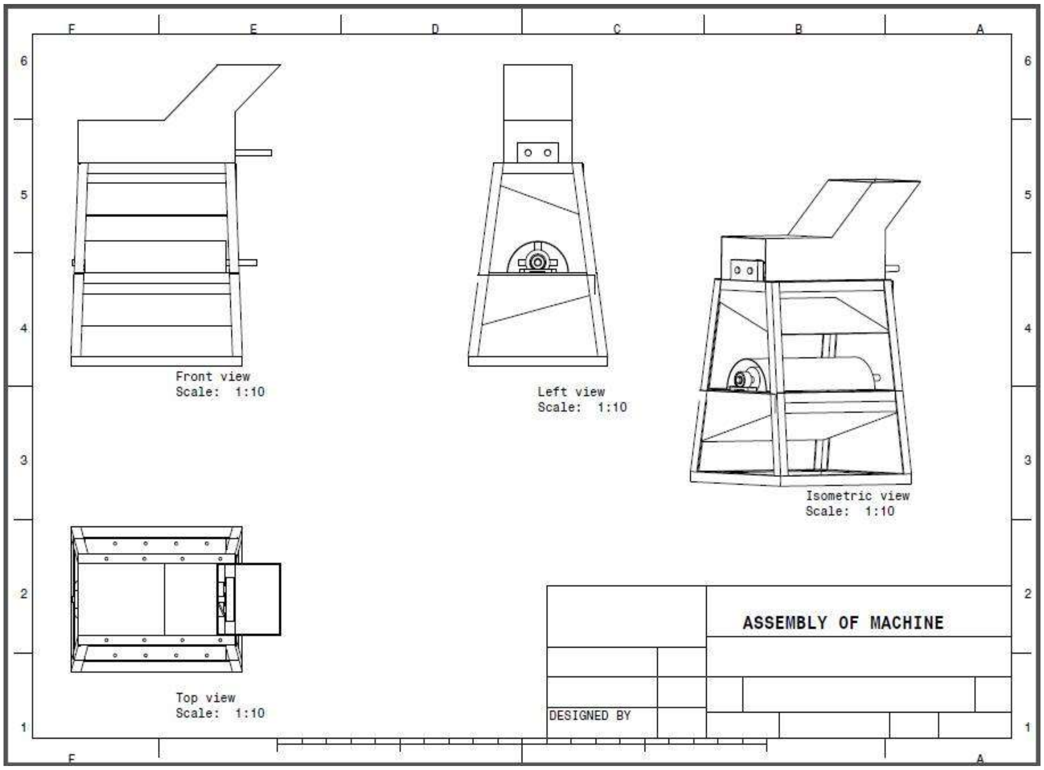
C = 476mm

Bearing Selection:-

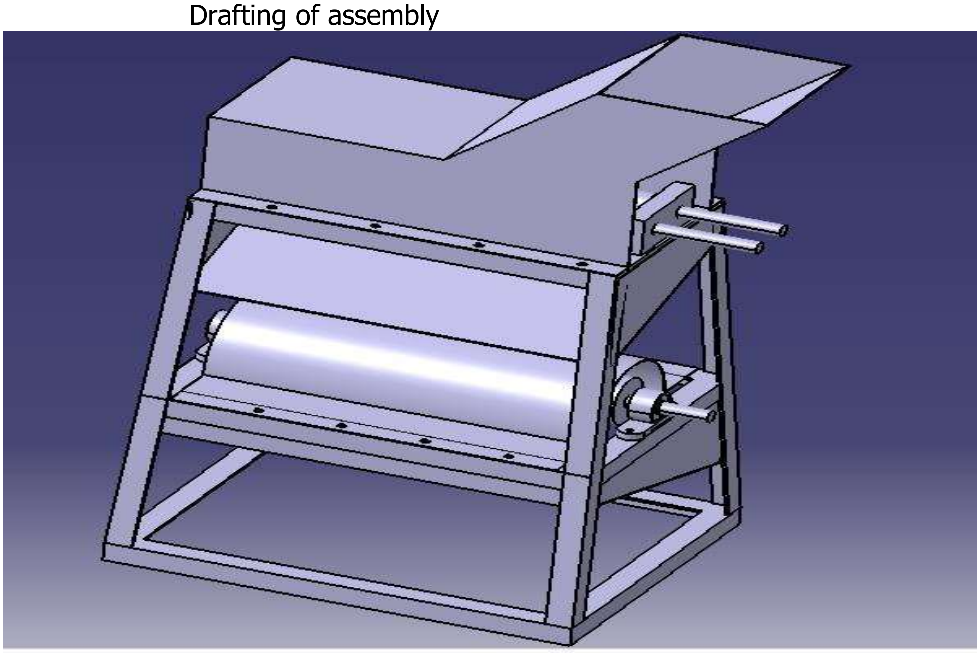
Bearing must be selected based on its load carrying capacity, life expectancy and reliability (PSG Tech 1989).
The relationship between the basic rating life, the basic dynamic rating and the bearing load is:

$L = 60n/10^6$ million revolutions, therefore, $L10 = (106/60n) \times [C/P]K$,
From calculations select standard bearing for 25 mm diameter shaft is 6205.

V. ASSEMBLY OF MACHINE



Drafting of assembly



Drawing of assembly

Design Operation

The average threshing plate speed is 600rpm. This corn sheller comprises of a hopper design to take three corn cobs lying on its vertical axis ZY plane, a threshing plate with spikes that simulates the tangential force applied to the surface of the corn, supporting frame-work, a threshing wall that has groves where the falling corn rotates, and an adjustable spring, that allows the threshing wall adjust to the different sizes of the corn. It also had a container for storage besides the threshing cylinder and hopper. The shaft length was 1297.23mm while the shaft diameter is 25mm.

The angular velocity (ω) is 73 rad/sec, with a maximum available threshing force of 501.2N at the tip of spikes. The torque developed at the spike is 36.45Nm. The power delivered at the threshing spikes is 2.92kW, which means that prime mover is 1hp Electric motor.

There are also engineering design factor that affect the design of mechanical shellers. These factors are the design of the power transmission shaft, selection of the prime mover, type of pulley, appropriate belt design, key and selection of appropriate bearings support.

TESTING AND RESULT

Results

The human mechanical efficiency was determined to be 45% at the biomaterial test weight of 20kg with actually shelted grain weight of 15.8kg. The human throughput capacity was 26.67kg/hr and actual grain handling capacity of 21.1kg/hr at a shelling time of 45mnutes or 0.75hr. This result is base on the spot assessment of shelling done by five selected farmers from different farm settlement, although this efficiency will drop due to increase drudgery. The efficiency and throughput capacities of were 86% and 119.76kg/hr respectively. When further evaluation was carried to determine the actual grain throughput capacity based on actual weight of grain threshed but not broken the capacity was 109.99kg/hr. The result showed that the shelter was effective.

Testing of Corn Threshing Machine

1. Time required to threshing of 100kg corn is 20minutes.
2. The average threshing capacity of machine is 300 kg/hrs.
3. Machine can remain in working position as long as electricity gets supplied to motor.
4. Threshing efficiency of this machine is 90%
5. As load increases, speed decreases.

REFERENCES

Abdulkadir, B.H., Mattew, S.A., Olufemi, A.O., and Ikechukwu, C.U. (2009). The Design and construction of maize threshing Machine. Assumption University Journal of Technology, 12(3) pg. 199 - 206.

Alwan, S. K., Arabhosseini, A., Kianmehr, M. H., & Kermani, A. M. (2016b). The effect of two types of machines (hulling and bleaching) on some qualitative characteristics of rice cv. Tarm Hashemi. Euphrates Journal of Agriculture Science, 8(3), 32-49.

Ayetigbo, M. O. (2001). Design and construction of maize sheller. PhD Thesis, Federal University of Technology, Akure, Nigeria.

Chilur, R., Sushilendra, V. P., Veeranouda, M., Yaranal, R. S., Hiregoudar, S., & Mareppa, N. B. (2014). Effect of operational parameters on dehusking cum-shelling effi ciency and broken grain percentage of maize dehusker-cum sheller. Int. J. of Sci. Res., 3(8).

Crawford G.W. and Lee G.A, (2003). Agricultural Origins in the Korean Peninsula. *Antiquity,*vol. 77, no. 295, pp. 87-95.

Dziki, D. (2004). Mechanical properties of single kernel of wheat in relation to debranning ratio and moisture content. Acta Agrophysica, 4(2), 283-290.

El-Gayar, S. M. (2005). Flax seeds cleaning and grading using vibratory apparatus. Misr. J. Ag. Eng, 22(3), 923-942.

History of corn shelling machine (2008 March) Available: http: www.livinghistoryfarms htm, Pp 1-2.

http: www.Vidhatamdian.com maize.com/maize-sheller htm Pp1-2 Pp 2-5

Hussain, S. Z., Naik, H. R., Rather, A. H., & Junaid Khan (2009). Comparative evaluation of horizontal maize cob sheller with traditional methods of maize shelling. Research on Crops, 10(1), 168-170.

Humburg, D. (2016). Chapter 37: Combine adjustments to reduce harvest losses. In: Clay, D.E., C.G. Carlson, S.A. Clay, and E. Byamukama (eds). iGrow Corn: Best management practices. South Dakota State Uni.

Joshi, H.C. (1981). Design and selection of thresher parameters and components. Journal of Agricultural Mech. In Asia, Africa and Latin America; Vol. 12(2), 61-70.

Miu, P. I. (1995). Modelares Procesului detreier la Combincle de Recoltat Cereale.(Mathematical Modeling of Threshing Process in Cereal Combine Harvesters). Unpublished PhDdiss. Bucharest: *'Politchnica' University of Bucharest, Romania*, pp. 80-95.

Nazzir, W. (2008). A Farewell to Alms: A Brief Economic History of the World. Cesar Tarrant MIddle School. p. 286. ISBN 978-0 -691-12135-2.

PSG Tech. (1989). Design data. Faculty of mech. Enginering, Poolamedu. Sathankulan Govindsany Naidu College of Technology (PSG Tech.) DV Printers, Coimbatore, India.

Tastra, I. K. (2009). Designing and testing an improved maize sheller. Agricultural Mechanization in Asia, Africa & Latin America, 40(1), 12-17.

Tindall (1983), & Messiaen (1992): "Corn is grown virtually everywhere, in tropical, subtropical andtemperate region where rain and irrigation isadequate".

William, L.A., (1953). Mechanical Power Transmission Manual Conover - Mast Publ. New York. NY, USA.

www.agroproductlimited.com