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Design and Prototype Development of Hybrid Ploughing, Seeding and Fertilizing Machine

(Mebrhit A.[1] Elias B.[2]Bezawit.D[3], Henok.B[4], Samual.N[5], Zenawi.T[6])
[1, 2] Ethiopian Institute of Technology-Mekelle, School of Mechanical and Industrial Engineering Manufacturing Engineering Chair, Mekelle-University, Mekelle – Ethiopia,
[3-6] Dire-Dawa Institute of Technology, Industrial engineering department, Dire-Dawa, Ethiopia,

ABSTRACT
This research work mainly focuses on design and prototype development of hybrid ploughing, seeding and fertilizing machine for typical Ethiopian farmers. In Ethiopia, the major tasks of farming include; ploughing, seeding and fertilizing. Since thousands of years until now the farming is dependent on oxen drawn plough plow. But, this system is labor intensive, time consuming and its depth of ploughing is shallow. These draw backs of existing agricultural system result in insufficient productivity. Now a day's modern agricultural machines are being imported into the country. But they are used by few organizations, small agriculture investors and few rich farmers. In collaboration with the Ethiopian Agricultural Transformation Agency, relevant data was collected on the gap of existing trial mechanisms and the need of farmers. To analyze the collected data and arrive at final output, methodology procedures followed by the researchers were; organizing the special design needs of end user, analyzing six alternative design concepts, selection of one optimal concept, detail dimensional design of selected concept, force analysis using the mechanics, dynamics and kinematics, preparing 2D and 3D drawings using Auto CAD and CATIA then finally prototype development. For the case of its economical applicability for poor Ethiopian farmers, the researchers assured that, it is low cost by conducting cost analysis. Unique features of this new design include; simultaneous ploughing, seeding, and fertilizing of multi lines, its mechanism for seeding variable size grains and for specifying their spacing, its control system relationship with the wheel rotation, its easiness to operate and maintain, its minimal damage to the seed during the process, its high level of operational reliability and its suitableness for modification based on capacity of the user. Therefore, using this machine will result in considerable improvements in productivity of the majority of Ethiopian farmers at lower cost.

Keywords: *Hybrid Ploughing, Ethiopian farmers, Agricultural transformation, seeding, fertilizing*

I. INTRODUCTION

Agriculture is the foundation of Ethiopian economy. It contributes approximately 46 % to the national GDP and employs over 80 % of the population. The agriculture sector has grown at a high rate of 8% per year. The government has created the Agricultural Transformation Agency of Ethiopia to build on this progress and drive the transformation of the agriculture sector to realize the interconnected goals of food security, poverty reduction, and human and economic development. Ethiopia's current Five Year Growth and Transformation Plan (GTP) establish ambitious targets for agriculture for 2011-2015. The targets focus on enhancing the productivity and production of smallholder farmers and pastoralists, Strengthening marketing systems, improving participation and engagement of the private sector, expanding the amount of land under irrigation, and reducing the number of chronically food insecure households.

II. LITERATURE SURVEY

Different literatures indicated that, the traditional farming is basically not productive, uneconomical and exasperating for workers involved. As stated by (Dessai et al. 1997) sowing okra by hand increases production cost as extra man-hours is required for thinning operation as excessive seed is inevitably sown per hill. Moreover, the traditional planting method is tedious, causing fatigue and backache due to the longer hours required for careful hand metering of seeds if crowding or bunching is to be avoided. [Kumar et. al. 1986] developed a manually operated seeding attachment for an animal drawn cultivator. The seed rate was 43.2 kg/hr. while the field capacity was 0.282ha/h. Tests showed minimal seed damage with good performance for wheat and barley. [Simalenga and Hatibu 1991] tested the Magulu hand planter on the field and found the work rate of the planter to be between 18 man-hours per hectare and 27man-hour per hectare when using conventional hand-hoe planting method. [Gupta and Herwanto 1992] designed and developed a direct paddy seeder to match a two-wheel tractor. The machine had a field capacity of about 0.5ha/h at a forward speed of 0.81m/s. Damage due to the metering mechanism was nil for soaked seeds and 3% for peregrinated seeds. [Ladeinde and Verma 1994] undertook a study to compare the performance of three different models of jab planters with the traditional method of planting. In terms of field capacity and labor requirements, there was not much difference between the traditional planting method and the jab planters. However, backache and fatigue were substantially reduced while using the planters. [Molin and D'Agostini 1996] developed a rolling punch planter for stony conditions, using 12 spades radially arranged with cam activated doors and a plate seed meter. Preliminary evaluation showed important improvement in the planting operation with reduction inhuman effort, more accurate stands and high field capacity. To attain optimum planting condition for productivity, [Pradhan et. al. 1997] developed a power tiller-operated groundnut planter cum fertilizer drill with an actual field capacity of 0.160 ha/h. Roshan v Marode. etal, 2013 work on design and implementation of multi seed sewing machine. However, it has productivity limitation, its feed rate mechanism is not well analyzed and it doesn't include soil covering mechanism.

Problem Statement

Based on current situation of Ethiopian's agricultural system, the cultivation of crops is still laid on traditional oxen driven mechanism. During farming the most over looked steps are ploughing, seeding and fertilizing as shown in fig (1). To work with this system one person is required to control the straight line path, one person to put the seeds and other person to distribute the fertilizer. Moreover, similar repetitions are going to be done for ploughing, seeding and fertilizing the whole surface area. As a result, there is high wastage of human energy, time and effort. All these lead to insufficient productivity and tiredness of Ethiopian farmers.

Fig. 1 plough and seeding system

OBJECTIVES

2.1 General objective

Design and prototype development of hybrid ploughing, seeding and fertilizing machine for Ethiopian farmers in order to increase productivity, reduce unwanted labor utilization and time consumption.

2.2 Specific objectives

- To organize special design needs of the farmers
- Concepts generation as alternative solutions
- Analyzing alternative design concepts
- Selection of one optimal concept
- Detail dimensional design of selected concept
- Force analysis using the mechanics, dynamics and kinematics
- Preparing 2D and 3D drawings using Auto CAD and CATIA
- Prototype development

III. METHODOLOGY

3.1 Data Collection Methodology

Primary data sources

- Interview to Ethiopian Agricultural Transformation Agency concerned bodies
- Interviewed farmers
- Field observation of Ethiopian's agricultural practices

Secondary data sources
- ✓ Design text books, reference books, previous researches, and papers
- ✓ Relevant documents from Agricultural Transformation Agency of Ethiopia

3.2 Data analysis methodology
- ✓ Technical interpretation of farmer's design needs
- ✓ Concepts generation for design
- ✓ Analyzing alternative design concepts by assigning weight and selection of one best concept
- ✓ Detail dimensional design of selected concept
- ✓ Force analysis using the mechanics, dynamics and kinematics
- ✓ 2D and 3D drawings by Auto CAD and CATIA
- ✓ Cost analysis using ABC costing method
- ✓ Prototype development

IV. DATA ANALYSIS AND DESIGN

4.1 Summary of Farmer's Design need Data

Question	**Customer statement**	**Interpreted need**
Have you ever see a problem in traditional plough?	Yes, we see	• Out date mechanism • Wastage of energy • Time consuming
What improvement would you prefer for the traditional plough system?	using easy mechanism and reducing of labor force	• Easy to operate • Use mechanical machine • No need of skill person to operate
What do you think if traditional plough replaced by machine?	Yes, it is better to replace	• Change in production rare • Use technology • Avoid unnecessary force
What solution do you think for traditional plough system?	-Easy to operate and manufacture in Ethiopia. -Operate at same time plough and seed	• Less cost • Increase production rate • Mechanical operation helps to operate simultaneous operation • Easy to maintain
Is there a difference with the production rate between the traditional and modern one?	Yes, there is effect on seeding and help use line plough	• Functional at anywhere. • Increasing number of plough lines per unit time • Design the machine considering the standard of plough of one line to the other

Table1. Farmer's data template

4.2 Organizing needs into a hierarchy
1. Easy to operate and plough
2. Less labor and functional at anywhere
3. Ease of manufacture
4. Easy to maintain
5. Less cost
6. Pulling system can use motor or other mechanism like oxen:
7. Avoid unnecessary force

4.3 Concept generation
Concept generation is a key activity in the engineering design process. Design Wisdom holds that increased concept generation in the initial phases of design Leads to better design outcomes. One common way to represent design cognition is by sketches, list out the working principle and parts. Based up on the customer need requirements, we generate ***six new*** ideas.

4.4 Concept selection criteria
Concept selection is an integral part of the product development process; it is the process of evaluating concepts with respect to customer needs and other criteria, comparing the relative strength and weakness of the concepts. This is basically based up on the customer or end user requirements interpretations which are listed above in the organizing needs in to hierarchy portion.

Method: Weight assignment and rating
Concepts Performance rating:
Poor – 1, Good- 2, Very good – 4, Satisfactory - 3, Excellent- 5

Selection criteria	**Weight %**	**Concept**					
		1	2	3	4	5	6
Easy to operate and plough at same time seed and fertilizer.	20						
Less labor and functional at anywhere.	10						
Ease of manufacture and	10						
Easy to maintain.	10						
Less cost.	20						
Pulling system Can use Motor or other mechanism like oxen	15						
Avoid unnecessary force.	15						

Table.2. Weighting criteria and concepts rating

Rank the concepts
Once the ratings are entered for each concept, weighted scores are calculated by multiplying the raw scores by the criteria weights. The total score for each concept is the sum of the weighted scores.

$$s_j = \sum_{i=0}^{n} r_{ij} w_i$$

Where
r_{ij} = raw rating of concept j for the ith criteria
Wi = weighting for the ith criteria
n = number of criteria
s_j = Total score for concept j

Concept scoring matrix

Selection criteria	W %	1		2		3		4		5		6	
		R	s	R	s	R	s	R	s	R	s	R	s
Easy to operate and plough at same time seed and fertilizer.	20	4	0.8	4	0.8	4	0.8	4	0.8	5	1	2	0.4
Less labor and functional at anywhere.	10	4	0.4	1	0.1	1	0.1	1	0.1	4	0.4	3	0.3
Ease of manufacture and	10	3	0.3	4	0.4	3	0.3	4	0.4	4	0.4	4	0.4
Easy to maintain.	10	3	0.3	4	0.4	3	0.3	3	0.3	3	0.3	5	0.5
Less cost.	20	4	0.8	4	0.8	4	0.8	3	0.6	4	0.8	4	0.8
Pulling system Can use Motor or other mechanism like oxen	15	4	0.6	3	0.45	3	0.45	3	0.45	4	0.6	1	0.15
Avoid unnecessary force.	15	4	0.6	1	0.15	1	0.15	1	0.15	4	0.6	1	0.15
Total score		3.8		3.1		2.9		2.8		4.1		2.7	
Rank		2		3		4		5		1		6	
Continue		No		No		No		No		yes		No	

Table.3. Concepts score results

Where, W% = weight in percent, R = rate S = score

4.5 Selecting best concept
Each concept is given a rank corresponding to its total score, as shown in the above table. Some the most creative refinements and improvements occur during the concept selection process realizes the inherent strengths and weaknesses of certain features of the product concepts. Therefore, concept five achieves the highest ranking after the first pass through the process and it is going to be developed.

4.6 Designing of the Components

1. Design of axle
2. Design of wheel.
3. Design of horizontal shaft
4. Design of seed and Fertilizer box
5. Design of Seed controlling system
6. Design of seed covering mechanism
7. Design of the furrow opener
8. Fertilizer and seed tube
9. Seed control system

4.7 Design of axle

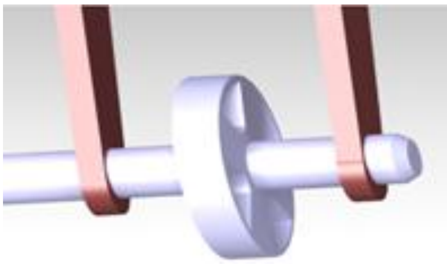


Fig.2 wheel axle

The material selected for the axle should have higher bending strength and shearing strength. So meet these requirements steel is selected.

I:AISI number	Treatment	σ_t MPa	σ_y MPa
1020	Annealed	394.7	294.8

Table.4. materials and their stress (Juvinall)

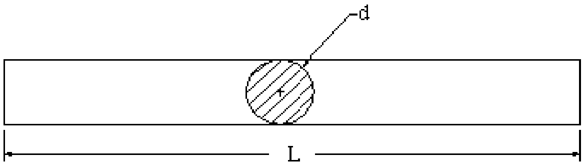


Figure 3: The axle free body

100 N loads is the approximated weight of the seed box, seed itself and the controlling disc. There are four sets of seed box, and controlling disc. Therefore the total weight applied on the axle will be 400N.
The reactions R_1 and R_2 are the support forces of the wheel.

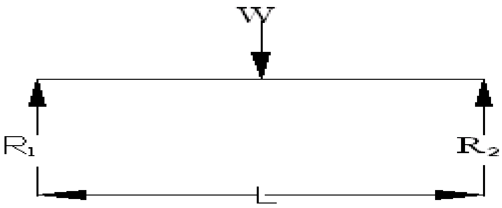


Figure 4: Free body diagram of the axle

We brought the forces applied to the mid-point. The axle is considered as simply supported beam. Therefore, the maximum moment can be calculated as follows:

$$\sum F_x = 0$$
$$R_1 + R_2 = 400N$$

But from symmetry R1 and R_2 are equal.

Therefore $R_1 = R_2 = 200N$

And $M_{max} = FL/4 = 400N * 700mm/4$
$= 70000$ N-mm
$= 70$ Nm

The maximum moment is at the middle of the axle

Deflection or bending consideration

Taking safety factor to be 2

$$\sigma_b = \sigma_y / SF = 147.4 Mpa$$

147.4 MPa is the allowable bending stress

To find the dimension of the axle

$$\sigma_b = \frac{M_{max}}{Z}$$

Where Z is section modulus and it is calculated as follows

$z=\pi d^3 / 32$

For a circular cross section so,

147.4 MPa =70000/ πd^3 / 32

d= $(147.4\pi/32 * 70000)^{1/3}$ = 16.915 mm

We can take the diameter as much as we want as far as it is greater than 16.915mm to meet other requirements. So, let us take it to be 20mm.

Design for shear stress

The shear stress is applied at the wheel positions and it is due to the shear force of 200N.

$$\tau = \frac{F_s}{A_s}$$

Where

Fs is the sheer force applied as is the shear area

$$\tau = \frac{F_s}{\pi d^2 / 4}$$

=200 *4/400π = 0.635MPa

So, the shear stress applied on the axle is less than the allowable stress. So, the aforementioned diameter is safe.

4.8 Design of ground wheel

Diameter is selected mainly based on machine height. The width of wheel depends on *type of soil and wheel* sinking. The wheel going to be designed is the one on the axle for a required dimension. It rotates with the axle at a translational speed of 0.4m/s and rotational speed of 19.1rpm. The diameter is assumed to be 200mm. This diameter is taken to match furrow height and the controlling disc extension down the axle. The metering disc is directly mounted on the axle. Now, let us proceed to the design of different parts of the wheel. In wheel design parameter the wheel diameter needs to be ranging from 10cm – 40cm. So enough space is provided along the axle to slide it sideways and fix where required.

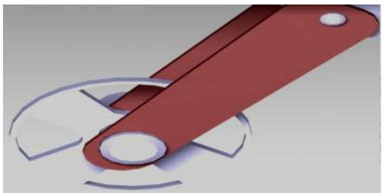


Fig.5 Ground wheel

<u>Note: -</u> we select wheel with pegs type and 20cm diameter for safe design.

Design of Shaft

Shaft Materials

The material used for ordinary shafts is carbon steel of grades 40 C 8, 45 C 8, 50 C 4 and 50 C 12.When a shaft of high strength is required, then an alloy steel such as nickel, nickel-chromium or Chrome vanadium steel is used. For my shaft design researchers select shaft material 50 c 4.

Table.5. mechanical properties of steel used for shaft

Material type	Yield strength	Ultimate tensile strength
50 C 4	370 MPa	700 MPa

Endurance Limit Modifying Factors on Horizontal Shaft

$S_e = k_a k_b k_c k_d k_e k_f S'_e$

Where, k_a= surface condition modification factor K_b= size modification factor

Kc= load modification factor

K_d= temperature modification factor

K_e= reliability factor

K_f= miscellaneous-effects modification factor

S'_e= rotary-beam test specimen endurance limit

S_e= endurance limit at the critical location of a machine part in the geometry and condition of use When endurance tests of parts are not available, estimations are made by applying Marin factors to the endurance limit.

A. Surface Factor k_a

The data can be represented by $Ka = aS^b_{ut}$

Where S_{ut} is the minimum tensile strength and a and b are to be found from standard table

Surface finish factor a	S_{ut},Kpsi	S_{ut},Mpa	B
Ground	1.34	1.58	-0.085
Machine or cold –drawn	2.70	4.51	-0.265
Hot-rolled	14.4	57.7	-0.718

Table.6. Standard table for minimum tensile strength

Where S_{ut} is the minimum tensile strength and a and b are to be found in Table**.** From standard table a= 4.51 and b =−0.265. Then, $K_a = 4.51(370)^{-0.265} = 0.94$

B. Size Factor k_b

The size factor has been evaluated using;

$$K_b = 1.51d^{-0.157}$$

$(D/7.62)^{-0.107} = 1.24d^{-0.107}$, $2.79 \le d \le 51$ mm

$1.51d^{-0.157}$, $51 < d \le 254$ mm

For axial loading there is no size effect, so k_b= 1

C. Loading Factor k_c

When fatigue tests are carried out with rotating bending, axial (push-pull), and torsion loading, the endurance limits differ with Sut. Here, we will specify average values of the load factor as

$$K_c = \begin{bmatrix} 1 & bending \\ 0.85 & axial \\ 0.59 & torsion \end{bmatrix}$$

D. Temperature Factor K_d

Any stress will induce creep in a material operating at high temperatures; so assuming operating temperature 50^0c.

Temperature	$ST/_{Srt}$
50	1.000
100	1.010
150	1.020
200	1.020
250	1.000

Table.7. standard table for temperature factor

There for $K_D = \frac{ST}{SRT} = 1.000$

E. Reliability Factor K_e

Data presented by Haugen and Witching show standard deviations of endurance strengths of less than 8 percent. Thus the reliability modification factor to account for this can be written as

$k_e = 1 - 0.08\, z_a$

Where z_a is defined by and values for any desired reliability can be determined from Table gives reliability factors for some standard specified reliabilities.

Take value of k_e0.868.

Reliability, %	Transformation variateZ_a	Reliability factor K_e
50	0	1.000
90	1.288	0.897
95	1.645	0.868
99	2.326	0.814
99.9	3.091	0.753

Table.8. standard table for reliability factor K_s

F. Stress Concentration and Notch Sensitivity

Notch sensitivity q is defined by the equation

$$q=\frac{KF-1}{KT-1} \quad \text{or} \quad q_{shear}=\frac{kfs-1}{kts-1}$$

Where q= usually between zero and unity. Equation shows that if q = 0, then K_f= 1, and the material has no sensitivity to notches at all. On the other hand, if q = 1, then K_f= K_t, and the material has full notch sensitivity. In analysis or design work, find K_t first, from the geometry of the part. Then specify the material, find q, and solve for K_f from the equation.

$K_f = 1 + q(K_t - 1)$

$K_{fs} = 1 + q_{shear}(K_{ts} - 1)$; for steel materials k_t=1.65

K_t=1.65

Kf= 1 + 0.85(1.65 − 1) =1.55

No	Factors name	Factors symbol	Factors value
1	surface condition modification factor	k_a	0.98
2	size modification factor	K_b	1
3	load modification factor for torsion	k_{ct}	0.59
4	load modification factor Axial	k_{ca}	0.85
5	load modification factor Bending	k_{cb}	1
6	temperature modification factor	k_d	1.000
7	reliability factor	k_e	0.868
8	Miscellaneous-effects medication factor	k_f	1.55
9	Stress concentration factor	k_t	1.65

Table.9. Summary for value of endurance limit factor

The endurance limit

$S'e=0.5SU = 0.5 \times 700 = 350 Mpa$

✓ **The endurance limit for bending**

$S_e = k_a k_b k_c k_d k_e k_f S'_e$

$S_e = 0.94 \times 1 \times 1 \times 1.000 \times 0.868 \times 1.55 \times 350$

=442.63MPa

✓ **The endurance limit for torsion**

$S_e = k_a k_b k_c k_d k_e k_f S'_e$

$S_e = 0.94 \times 1 \times 0.59 \times 1.000 \times 0.868 \times 1.55 \times 350$

=261.15Mpa

✓ **The endurance limit for axial load**

$S_e = k_a k_b k_c k_d k_e k_f S'_e$

$S_e = 0.94 \times 1 \times 0.85 \times 1.000 \times 0.868 \times 1.55 \times 350$ =376.24Mpa

4.9 Design of horizontal shaft

Horizontal shaft layout

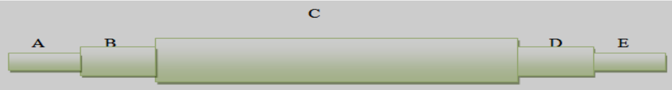


Figure.12. horizontal shaft layout

Length of the Horizontal shafts

A= clearance , B= Belt for Left side wheel

C= Space between two wheels, D= Belt for Right side wheel, E=clearance

Assumption of total length of horizontal shaft= A+B+C+D+E=40+30+460+30+40

Assume total length of shafts became L =540mm

Input Shaft design is based on the ASME equation:

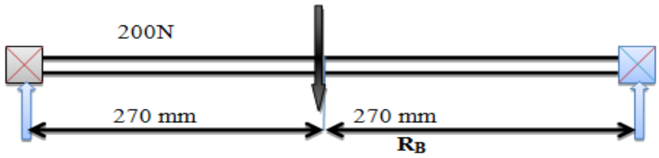
$T=\frac{60P}{2\pi Np}=\frac{60*82.02W}{2\pi*19.1}=41.1Nm$

Note: - To calculate the maximum bending moment we must assume the weight of seed and fertilizer, weights of vertical shaft, seed and fertilizer box weight, frame weight including load on belt. Take 200N

$M=\frac{WRL}{4}=\frac{200*.0.600}{4}=30Nm$

Reaction forces

- **Reaction Forces for resultant Loads**



Shear force and bending Moment Diagram

- **For resultant Loads**

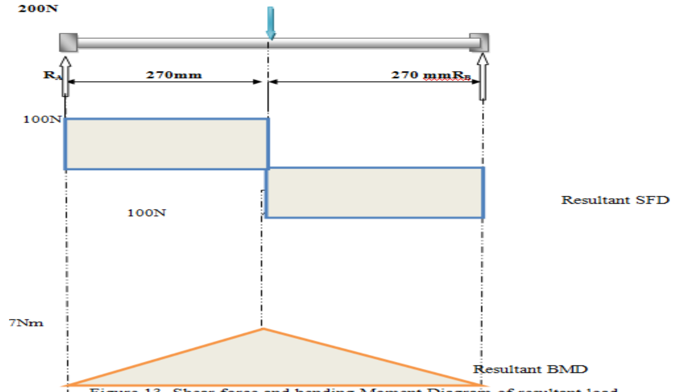


Figure.13. Shear force and bending Moment Diagram of resultant load

Minimum diameter calculation

By ASME code equation for shaft design we have combined shock and fatigue factors for ASME code shaft design equation

Type of loading	K_b	K_C
Gradually applied load	1	1.0
Suddenly applied load		
With minor shocks	1.5-2.0	1.0-1.5
With heavy shocks	2.0-3.0	1.5-3.0

Table.10. Values of k_b and k_c

k = 0.2 i.e., 20% reduction in strength due to keyway is assumed. From Table above, for rotating shaft with minor shock loads, K_b = 1.5 and Kc = 1.0.

by Taking 50 C4 steel for the shaft, σ_{yp}= 370MPa

$\tau_{yp}=\sigma_{yp}/3$

=370/3 = 123.33 MPa and taking factor of safety of 3 [τ]

Input Shaft design is based on the ASME equation:

$T=\frac{60P}{2\pi Np}$

$T=\frac{60*82.02W}{2\pi*19.1}=41.1Nm=41.1\times10^3 Nmm$

Bending moment

$M=\frac{WRL}{4}=\frac{200*.0.600}{4}=30\times10^3$ Nmm

Equivalent twisting moment

$T_E=\sqrt{(KbM)^2+(KtT)^2}$

$=\sqrt{(1.5\times30000)^2+(1\times41100)^2}$

=60944.32Nmm

$d^3 = \frac{16}{\pi(1-k)\tau}\sqrt{(KbM)^2 + (KtT)^2}$

$d^3 = \frac{16}{\pi(1-0.2)123.33}(60944.32\text{Nmm})$

d=14.65mm

- Note: - The minimum design diameter is 14.56mm.we can take any value of standard diameter of shaft above 14mm. The standard sizes of transmission shafts are: 25 mm to 60 mm with 5 mm steps and 60 mm to 110 mm with 10 mm steps. Therefore we select shaft have 25mm diameter.

Design of seed and Fertilizer box
Design of seed box

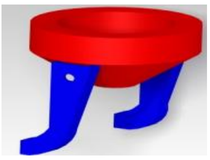


Figure14. Seed box

Cylinder shape of seed and fertilizer boxes is generally used in the machine for free flow seed. Volume of seed box is given by

V_b=1.1Vs where V_b=volume of seed box cm^3

Vs=volume of seed box cm^3

Also $V_S = \frac{Ws}{\gamma s}$ where Ws=weight of seed in the box g

γs=bulk density of seed g/cm^3

Combine the above two equation

$V_b = 1.1\frac{Ws}{\gamma s}$

- For light easy operation of the drill, take 2 kg seed is filled in the box at a time.

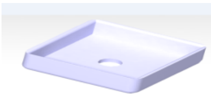
No	Type of seed	Bulk density (g/cm)
1	Wheat	1.118
2	Green gram	1.12
3	Bajra	0.62
4	Gram	0.82

Table.11. Types of seed density

The maximum bulk density of all seed is the wheat seed density. Therefore take wheat bulk density 1.118 g/cm.

$Vb = \frac{1.1*2kg*1000g/kg}{1.118g/cm^3}$ =1967.79cm^3says 2000cm^3.

Fertilizer box



Figur15. Fertilizer box

For easy construction, balanced operation of seed cum fertilizer drill and symmetry in size, the same volume and shape of fertilizer box is selected as that of seed box.

Therefore volume of fertilizer box V_f =2000cm^3

Bulk density of fertilizer γ_f=1.2g/cm^3

$Vb = \frac{1.1*2kg*1000g/kg}{1.2g/cm^3}$ =1833.33cm^3 we can take of the volume of seed box 2000cm^3

Total volume of seed box is two times of fertilizer box

Total seed box volume =2$\times$ fertilizer box

=2$\times$2000cm^3= 4000cm3

Assume the minimum height of the box for both fertilizer and seed h=20cm.Radius of seed box can calculate from formula of cylinder

$V = h \times \pi \times R^2$

$R_{\text{seed box}} = \sqrt{\frac{V}{h*\pi}} = \sqrt{\frac{4000\ cm^3}{20cm*\pi}}$ =7.978cm say 8cm and give clearance 2cm then

$R_{\text{seed box}}$=10cm

$R_{\text{fertilizer box}} = \sqrt{\frac{V}{h*\pi}} = \sqrt{\frac{2000\ cm^3}{20cm*\pi}}$ =5.64cm say 6cm and give clearance 2cm then

$R_{\text{fertilizer box}}$=8cm

Design of Seed controlling system

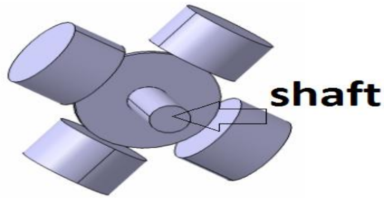


Figure16. Seed controlling system and shaft

Seed controlling is the main part in the Hybrid ploughing seeders. Hence its design needs critical attention. As we have discussed in the conceptual design topic, we chose plate type controlling device. The material is chosen to be a sheet metal.
The diameter of the ground wheel is 200mm.The maximum diameter of the seed controlling plate is 40mm.
Let's take the diameter of seed controlling to be 30mm.
The speed of the oxen is 0.4m/s (from reference).
When the wheel rotates once the oxen travel 3.14*200= 628mm. In this distance 628/100 wheat seeds should fall. And 628/250 maize seeds should fall.

- Wheat seed per rotation of the wheel = 6.28 =7
- maize seed per rotation of the wheel = 2.512 = 3

The number of holes in the controlling plate for wheat is calculated as 3.14*30= 94.2 when the wheel rotates once the controlling plate also rotates once. Per rotation the plate should deliver 7 wheat seeds and 3 maize seeds.360/7= 51.428 at degree the holes arranged. If the cut out the circumference of the plate is 3mm for wheat, the total length of the cut out will be 7*3 = 21mm. The uncut length between holes is 94.2-21 = 73.2mm.The length between two holes can be calculated as 73.2/7 =10.45mm
So, the dimensions are all safe.

Design of the seed delivery system

Figure.17. seed delivery system

Design of seed soil covering mechanism

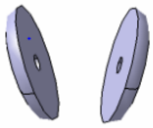


Figure18.Concave dice

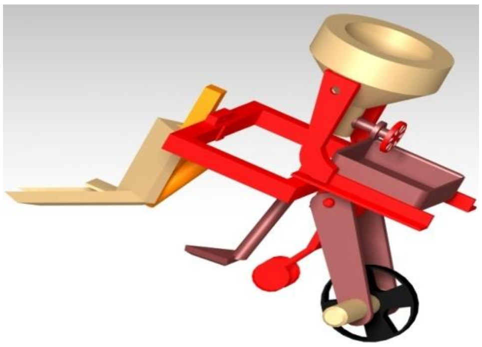
Design of the furrow opener

Figure19. Furrow opener

Distance of draft application on furrow opener is:
a=h/3=20/3=6.66cm
Moment arm length =h-a= **(**20-6.66**)=**13.34cm

Bending moment =D(h-a) =15kg×13.34cm=200kg-cm
=200kg-cm×10N/kg×10mm/cm =20000Nmm
Take factor of safety =2
Therefore, maximum bending moment =20000Nmm× 2=40000Nmm
Note: - It is assumed the M.S flat Tyne is used in the belt control, f_b=56N/mm^2 for mild steel
Also section modulus of Tyne (Z) =Mb/f_b
=40000/56=714.2mm^3
Take b=20mm size flat
t=Thickness of flat, mm
Z= (1/6) t b^2 (for rectangular section)
714.2=1/6×t(20)^2 (b=20mm assumed)
t= (6× 714.2/400) =10.7mm
Note: - so M.S flat of 20× 10mm size is quite safe for the furrow opener. but, in the market 35×10mm size M.S flat is available which is selected for the furrow opener of the machine

Complete assembly of the manual hybrid ploughing, seeding and seed machine
Working principle: The ground wheel will rotate when it pulled by any method, mean by oxen or by motor. In addition, the rotational motion from the ground wheel is transmitted by V-belt to the seeding interval controlling mechanism (smaller axle and disk assembly) so that, seeding at intervals is possible. This coordination results in simultaneous ploughing and seeding. But the fertilizer flows continuously at initially adjusted flow rate (has flow rate valve). Next to these operations it covers the borrowed/ ploughed line by soil at the left and right with the help of circular flatty pans arranged suitably. The machine can plough at a time at least six line. No need of human supporter to keep the line.



V. CONCLUSIONS

- The current agricultural system in Ethiopia has daw backs in the mechanism of seeding, ploughing and distributing fertilizers.
- This results in low productivity, time consuming, requiring more effort and energy.
- In this research, great efforts have been done to design and develop suitable mechanism that minimizes the draw backs.
- As per the researchers' data, there is high demand for a product which reduces time, energy utilization and increase productivity.
- Six product design concepts were analyzed and one which is the best was selected for detail design and prototype development.
- Plough, seed, fertilize and cover by soil gently for multiple rows at a time. So that covers more area in once reducing labor utilization and turn back time for other rows.
- Can be used for range of grains/ crop types
- Able to seed at optimal intervals
- Therefore, this hybrid ploughing, seeding and fertilizing machine is ideal solution to traditional farming system in Ethiopia and then to assure food security.

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