RESEARCH AND DESIGN OF MULTIPURPOSE AGRICULTURE EQUIPMENT

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ABSTRACT

This Research paper is based on the various study conducted on use of Agriculture Machines in fields and how it can be modernized or optimized further for small to medium scale farmers and also to design multipurpose agriculture equipment. Various activities are conducted by various machines in agriculture field. Most of the machines are heavy and costly. Small scale farmers can’t afford heavy machineries. Also study shows that small or medium powered machines with optimum load are more economical and efficient than heavy machines. In this research paper we have also designed multipurpose equipment based on the requirements and initial concepts, which can be more economical and efficient for small to Medium scale farmers.

KEYWORDS: Agriculture, Multipurpose, Efficient, Equipment, Design, Study.

I. INTRODUCTION

Agriculture is the main part of many countries’ economy. It provides jobs to many people. Many industries are dependent on agriculture. Especially in India about 42-43 % employment comes from agriculture. Agriculture considers many factors like weather, type of crops, type of lands, land area etc. Due to socio-economic reasons amount of land per family or head is becoming less and less. This has led to increased no. of small and medium scale farmers. Now, Agriculture requires many activities to be done. Many of them are done by heavy machineries which are costly and yet to be accessible for small scale farmers. We have make efforts in the direction to use scientific methods and available technologies to make multipurpose agriculture equipment that can be used for small and medium scale farming for different types of crops. Research was done to prove that tractor with comparatively low power can be more economical and efficient. Also equipment or machine is designed based on various types of activities related to various types of crops. Design of equipment also considered information gained from previous studies as well.

II. METHODOLOGY

For experiment two tractors were used. One with high power (~92 kW) and one with low power (~59 kW). Skimming, Tilling, Cultivating and seeding was done using both tractors.

2.1 Operations with tractors

For heavy powered tractor width used was 3m in operations like heavy cultivation, plough, harrow, seeding etc. For conventional and conservational tillage. Where as for other tractor width was 2.6m for cultivation, plough for conservational and conventional tillage. And 3m for power harrowing and seeding.

Working depth used for heavy powered tractor were 3cm, 5cm, 10cm, 20cm, 25cm respectively for seeding (both conventional and conservational), stubble cultivation (both conventional and conservational), with heavy cultivator in conservational tillage, integrated tillage and mould broad plough for conventional tillage.

For other tractor working depth used was almost same.

For heavy tractor working speeds were 9.5 km/h, 7.5km/h and 8.1 km/h respectively for stubble cultivation, heavy cultivation and for seeding.

For other tractor working speeds were 9km/h, 7km/h and 7.8 km/h respectively for stubble cultivation, heavy cultivation and for seeding.
2.2 Measurements
For measuring fuel consumption flow meter was used. Consumption flow was measured using this equation (\(Q = \frac{f \times 3.6}{K_d}\))
Where \(f\)=frequency and \(K_d\)= digital factor for calibration 162 cm⁻³.

\[ Q = \frac{f \times 3.6}{K_d} \]

From the results, fuel consumption for 2nd tractor (~59kW) was 30-40% lower than the 1st tractor (~92 kW). It also showed that it was 37% more efficient to work for moving soil with the low powered tractor.

Hence we can say that fuel consumption, work time, machinery are important factors to make farming more profitable.

Also small tractor with optimal load will be more fuel efficient than a worse loaded heavy tractor.

III. DESIGN OF EQUIPMENT
Now, based on crops various activities are performed by machines. Like seeding, fertilizing, ploughing etc. To make basic equipment three concepts were selected as shown in the figures. Based on various parameters one concept was selected.
Concept 1

In first concept as shown in the figure one frame is used for mounting sprayer, cylinder of chemical for refueling purposes. Cylinder will be at centre. V shape Hooper is used for easy operations of flow of fertilizers and seeds. At the rear side inter cultivation will be placed.

Concept 2

In second concept we are using cubic shape frame as shown in the figure. Various attachments like flow pipe (fertilizers), sprayer and seeding will be assembled in shape of cubic entity. At the bottom side inter cultivation will be placed. Wheels are used with snipers for operations in wet land. However this structure is bulky and can't be easily operated by single operator. Otherwise it can be operated through motor or engine.
Concept 3

In third concept we are using bicycle like structure in which all equipments like sprayer (chemical) is mounted. While cylinder of liquid is placed at center to continue the flow. V shaped Hooper is mounted near the end means near the operator so activity of flowing fertilizers and seeding will be easy and continues. This concept results in low cost, easy transportation and low space requirements. Hence it can be suitable for developing multipurpose agriculture machine.

<table>
<thead>
<tr>
<th>Criteria/ Concept no.</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>manufacturing</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>designing</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>functions</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Ease of use</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Total +ves</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total -ves</td>
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<td>3</td>
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</tr>
<tr>
<td>Total zeros</td>
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<td>0</td>
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<tr>
<td>Overall score</td>
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<td>-1</td>
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<tr>
<td>ranks</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Basic layout of the model

Basic layout of the model consists bicycle like system in which front wheel is large and rear wheels are smaller. it has handle and space for attachments.
Frame of the vehicle

Most important factor for vehicle will be choosing materials. There many materials are available based on our requirements however ideally it should be light weight, easy to available, safe, recyclable and strong enough for agriculture activities. Material used for frame will be of steel. Steel is used for its characteristics as thermal mechanical and chemical resistant. Also it is widely available and it has ease of manufacturing also it is durable.

Design of ploughing tools

Ploughing tools requires hard material which can withstand high pressure while performing operations. Also it should have constant sharpness throughout its life for better results. Hence material used for ploughing tool will be High speed steel.
Design of seed metering device

This is the important part of our equipment because by seed metering we can use it for different types of seeds. It is required for spacing the seeds in the fields according to its type for better output. Data for some of the crops are mentioned below:

<table>
<thead>
<tr>
<th>Classification of Crops</th>
<th>Row to Row spacing<em>seed to seed spacing</em>depth In ‘cm’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal Crops</td>
<td></td>
</tr>
<tr>
<td>Major Cereal Crops</td>
<td></td>
</tr>
<tr>
<td>- Paddy/Rice : Oryza sativa</td>
<td>25cm<em>9cm</em>3cm</td>
</tr>
<tr>
<td>- Wheat</td>
<td>25cm<em>9cm</em>3cm</td>
</tr>
<tr>
<td>- Maize</td>
<td>40cm<em>15cm</em>5cm</td>
</tr>
<tr>
<td>- Barley</td>
<td>35cm<em>9cm</em>3cm</td>
</tr>
<tr>
<td>Major Millets</td>
<td></td>
</tr>
<tr>
<td>- Jowar</td>
<td>40cm<em>9cm</em>3cm</td>
</tr>
<tr>
<td>- Bajra</td>
<td>40cm<em>9cm</em>3cm</td>
</tr>
<tr>
<td>- Ragi</td>
<td>25cm<em>9cm</em>3cm</td>
</tr>
<tr>
<td>Pulse Crops</td>
<td></td>
</tr>
</tbody>
</table>
### Seeding Spaces According to Crops

<table>
<thead>
<tr>
<th>Grams</th>
<th>Seed Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red gram</td>
<td>85cm<em>25cm</em>3cm</td>
</tr>
<tr>
<td>Bengal gram</td>
<td>85cm<em>25cm</em>3cm</td>
</tr>
<tr>
<td>Chick pea</td>
<td>32cm<em>9cm</em>4cm</td>
</tr>
<tr>
<td>Black gram</td>
<td>32cm<em>9cm</em>4cm</td>
</tr>
<tr>
<td>Vignamungo</td>
<td>32cm<em>9cm</em>4cm</td>
</tr>
<tr>
<td>Green gram</td>
<td>32cm<em>9cm</em>4cm</td>
</tr>
<tr>
<td>Phaseolusaureus</td>
<td></td>
</tr>
<tr>
<td>Horse gram</td>
<td>32cm<em>9cm</em>4cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beans</th>
<th>Seed Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>32cm<em>9cm</em>4cm</td>
</tr>
<tr>
<td>Field bean</td>
<td>55cm<em>25cm</em>4cm</td>
</tr>
<tr>
<td>French bean</td>
<td>55cm<em>25cm</em>4cm</td>
</tr>
<tr>
<td>Lima bean</td>
<td>55cm<em>25cm</em>4cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peas</th>
<th>Seed Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pea</td>
<td>32cm<em>9cm</em>4cm</td>
</tr>
<tr>
<td>Cow pea</td>
<td>42cm<em>18cm</em>3cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil Seed Crops</th>
<th>Seed Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground nut/Pea nut : Arachishypogaea</td>
<td>30cm<em>10cm</em>4cm</td>
</tr>
<tr>
<td>Soybean : Glysine max</td>
<td>30cm<em>10cm</em>3cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Edible Oil Seeds</th>
<th>Seed Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground nut/Pea nut : Arachishypogaea</td>
<td>30cm<em>10cm</em>4cm</td>
</tr>
<tr>
<td>Soybean : Glysine max</td>
<td>30cm<em>10cm</em>3cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non Edible Oil Seeds</th>
<th>Seed Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linseed</td>
<td>80cm<em>20cm</em>3cm</td>
</tr>
<tr>
<td>Castor</td>
<td>80cm<em>20cm</em>3cm</td>
</tr>
</tbody>
</table>

**Table-2: Seeding spaces according to crops**
Seed metering disc uses call feed mechanism. In this mechanism first seeds are collected after that it is sowed or delivered at certain space.

Cells on device is generated that there are 15 degrees angle between them and seeds can be placed at certain distance say 10 cm apart, this distance can be changed in the multiples of 10 by putting seeds in alternate cells. Hence this mechanism provides us for almost all type of crop seeds. Closing of all cells can be make by any tap or any type of plaster.

Fig-7: Seed metering Disc

Seed hopper are used for continues flow of seeds with uniformity in the seeding device.

Fig-8: Seed Hopper
Fertilizer metering disc

Its design is same as seed metering device, it consists spike which can acts as stopper. This maintains flow of fertilizers every 15 degrees.

Fig-9: Fertilizer Metering Disc

Fertilizer hopper is also used for continuous and uniform flow.

It is made of CR of 16 guage.

Fig-10: Fertilizer Hopper
Container for seed metering
In this container seed are filled with the help of seed hopper. In this container seed metering disc uses cell type mechanism to lift seeds.

Fig-11: Seed metering Container

Container for fertilizer metering is based on the same concept as seed metering. In this container fertilizer is filled and pushed into fertilizer metering disc. This is also made up of CR of gauge 16.

Fig-12: Fertilizer metering Container
Below image gives us 3d view of seed metering device. It can be operated by motor as well. It shows us mechanism, it has parts like hopper, metering disc, rotor, furrow etc.

3.1 Various calculations on design

1. Design of shaft

For design of shaft equation of power will be,

\[ P = F \times V \]

We can assume that weight of the assembly will be around 55kg. Force will be acting on wheels. Now maximum force will be acting on rear wheels.

\[ F = m \times g \]

By taking \( m = 55 \text{kg} \)

\[ g = 9.8 \text{m/s}^2 \]

Now,

\[ F = 55 \times 9.8 = 539 \text{N} \]

Suppose, Velocity is will be 15cm/s i.e. \( V = 0.15 \text{m/s} \)

Thus

\[ P = 539 \times 0.15 = 80.85 \text{watts} \]

We can take torque as

\[ T = \frac{P \times 60}{2\pi n} \]

Considering Revolution numbers \( n = 50 \text{rpm} \)

Torque will be around \( T = \frac{80.85 \times 60}{2\pi \times 50} \)

\[ = 14.85 \times 10^3 \text{N-mm} \]

For shaft reactions will be,

Vertical reactions on fixed supports i.e, wheels

\[ R_A = R_B = \frac{(5+45+5)}{2} \]

\[ = 27.5 \text{kg} \]

\[ = 27.5 \times 9.8 = 269.5 \text{N} \]

Bending Moment will be around \( M = 1850 \text{Kg-mm} \)

For this shaft resultant moment will be

\[ M_r = (M^2 + T^2)^{1/2} \]

\[ = ((18.5 \times 10^3)^2 + (9.36 \times 10^3)^2)^{1/2} \]

\[ = 20.733 \times 10^3 \text{N-mm} \]

Now, shaft diameter can be given as,

\[ d = \left[ \frac{(M_r \times 16)}{(\pi \times \tau)} \right]^{1/3} \]

By Considering shear stress to be \( \tau = 55 \text{Mpa} \)

\[ d = \left[ \frac{(20.733 \times 10^3 \text{N}) \times 16}{(\pi \times 55)} \right]^{1/3} \]

\[ d = 12.581 \text{mm} \]

Now to choose standard diameter considering the actual working conditions
Take, diameter of shaft, \( d = 15 \text{ mm} \)

Calculating bending stress for shaft:

Considering the weight of 1600 N is acts on it,

Induced stress will be,

\[
\sigma = \frac{M}{Z}
\]

Where, \( M = \frac{WL}{4} \), \( W = \) load and \( L = \) Length

\[
M = \frac{1600 \times 1100}{4}
\]

\[
M = 412500 \text{ N/mm}
\]

Now, Section modulus can be given as

\[
Z = \frac{\pi}{16} \times d^3
\]

\[
Z = \frac{22}{16 \times 7} \times 353
\]

\[
Z = 8424.22 \text{ mm}^3
\]

\[
\sigma = \frac{412400/8424.22}{8424.22}
\]

\[
\sigma = 50.02 \text{ N/mm}^2
\]

So we can say that,

Induced stress < Allowed stress

\[
50.02 \text{ N/mm}^2 < 270 \text{ N/mm}^2
\]

It is established that design is safe.

Calculation on cutter

\[
P = 2\pi n T / 60
\]

\( P = \) Power, \( T = \) Torque, \( n = \) Speed of motor

Also, \( P = V \times I \) Where, \( I= \) Current Power input to the motor, \( V= \) Voltage

\[
Pin = V \times I
\]

\[
Pin = 12 \times 8
\]

\[
Pin = 96 \text{ W}
\]

Power output will be, (Motor to shaft)

\[
Pout = T \times \omega
\]

Motor Efficiency can be given as

\[
E = \frac{Pout}{Pin} 0.36
\]

\[
= \frac{T \times (2\pi \times N/60)}{96 T \times (2\pi \times 65/60)}
\]

\[
= 35.66 T
\]

Calculations for plough tools,

Take Depth of cut as 5 cm

Considering Speed of the tool as 2.5 km/hr = 41.64 m/hr

Take No. of tool= 5
Feed rate can be calculated as: \( \text{Rpm} \times N \times \text{CL FR} = 41.64 \times 5 \times 0.05 \)

We get Feed rate as, \( 10.41 \text{ m}^2/\text{min} \)

Calculation for seeding:

Speed = 32 rpm

Row spacing = 25 cm

Seed sowing time = 1.5 sec/per seed

Opening no. = 5

Seed dropping per minute = 5 \times 32 = 160 seeds

Hence, If the speed of the wheel is 46 m/min, then for 46 meter 160 seeds will be dropped.

Design for Welded Joint

In welded joint moment will be of pure nature of bending. So, we should design it for bending stress.

We know minimum throat area or weld area

\[ A = 0.706 \times s \times l \]

Where \( l \) = length of weld and \( s \) = size of weld

\[ A = 0.706 \times 5 \times (70 + 40 + 37 + 58 + 30) = 829.55 \text{ mm}^2 \]

For parallel fillet weld bending strength

\[ P = A \times F_b \]

\[ F_b = 85N/\text{mm}^2 \]

At the end of the lever load applied will be 260 N.

moment generated will be

\[ M = P \times L = 260 \times 450 = 117000 \text{ N} - \text{mm} \]

We know that

\[ M/Z = F_b \]

\[ Z = \left( \frac{B H^3 - bh^3}{6} \right) = \frac{(40^3 \times 755^3 - 35^3 \times 580^3)}{6} \times 75 = 308824 \]

induce stress developed will be,

\[ F_b \text{ induced} = \frac{117000}{308824} = 0.3788 \text{ N/mm}^2 \]

design is safe because induced stress is less than allowable stress, which is 56 N/mm²

Basic vehicle with chemical sprayer
3.2 Cost Analysis

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>COST (RS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BICYCLE</td>
<td>4000</td>
</tr>
<tr>
<td>INTER CULTIVATING AND PLOUGH ATTACHMENT</td>
<td>8000</td>
</tr>
<tr>
<td>CHEMICAL SPRAYER</td>
<td>3000</td>
</tr>
<tr>
<td>SEED SOWING EQUIPMENT AND ATTACHMENTS</td>
<td>8200</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td><strong>23200</strong></td>
</tr>
</tbody>
</table>

Fabrication and labor cost = Rs 7,000

Total cost = Component cost + Fabrication and Labor Cost
= 23200 + 7,000
= Rs 30700/

IV. CONCLUSION

From above study it can be concluded that conventional system with heavy tractor is less efficient and more time consuming than conservative system with low or medium power tractor. Also, the equipment or machine that is designed can be used for plough, seeding, fertilizing etc. It will be more economical and efficient than heavy machines for small to medium scale farmers.

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