# Design & Fabrication of Manure Spreader

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*Abstract*— Organic manure plays important role to yield productivity of soil. It is good quality source of nitrogen phosphorus and excellent source of calcium and potash. The evenly spreading of manure on farm field is extremely important to achieve better effect. In India traditionally manure has distributed with help of fork and other mechanical device which is very tedious and slow process. The study of existing literature of manure spreader shows there are mainly two types of spreader viz. animal drawn spreader and tractor operated spreader. Performance of available spreader on different parameter has been studied which shows tractor operated spreader gives better result. Study also focus on their limitations of design and source of power supply. There is scope of develop tractor operated spreader attachment which will driven by rear wheel of trailer. By dismantling the attachment we can use trailer for transportation.

***Keywords:*** Manure Spreader, Auger, Chain Driven Wheel

## I. INTRODUCTION

For fertilizing the field we need to provide cow dung to farm by manually. Organic manure is considered as eco-friendly bio-fertilizers. Crops need nutrients to grow and develop and they draw these nutrients from the soil. If this withdrawal is not compensated for, the crop yield goes down progressively. This withdrawal is completed through fertilizers and manures to maintain the productivity of the soil and to achieve higher yields. Soil fertilization is carried out by means of organic matter in the form of farmyard manure, liquid manure faces, plants or straw and mineral matters. The manure has to be handled in bulk. So, the problem faced during application of manure differs from that of other fertilizer not only with respect to the rate to be applied per hectare, but also with respect to non-uniformity of the size of the particles. The overall goal for any field receiving manure should be how many gallons or tons of manure should be applied to a known area and to apply the manure as uniformly as possible (Brace A. Mackellar and Lee W. Jacob).

### A. Background

In many developing countries, animal manure is anaerobically digested, sometimes in combination with human excreta, to produce biogas, which is used for cooking and/or basic lighting. Besides biogas, anaerobic digestion produces a residue, the so-called digestate or bio-slurry, which contains most of the nutrients of the original manure, partially in a converted form. This bio-slurry can potentially be used as an organic fertilizer.

Numerous studies have been conducted on the comparative value of bio-slurry as a fertilizer & its comparative value to farmyard manure. However, these studies do not provide a uniform message. The differences between the results of the studies can be due to several reasons, e.g. Bio-slurry source, storage and handling, crop types, soil and climate conditions, or differences in methodologies to assess the value of bio-slurry as a fertilizer.

### B. Problem Statement

Organic farming is generally considered as more labor intensive. The increase in labor requirement has been assessed as ranging from 15% to 40%.Manure spreading is done manually , So cost and time for that purpose is increases . So that's why we required mechanical manure spreader.

### C. Objectives

1) In conventional process of bio fertilizer spreading all work is done manually. This is a grueling process. So we want to minimize these manual efforts.
2) Spreading by conventional process requires 6 to 8 labors/acre. Now in India huge labor problem is there. So we want to reduce it.
3) To reduce the cost and time.
4) To provide bio fertilizers/ manure with our trolley, not manually.
5) To reduce work load of farmers.
6) '1' person is enough for manure spreader.

## II. CONSTRUCTION & DESIGN

Manure spreader consist of four main parts
1) Chain drive
2) Gear
3) Auger
4) Manure Box

### A. Chain drive

The chains are mostly used to transmit motion and power from one shaft to another, when the centre distance between their shafts is short. The sprockets and chain are thus constrained to move together without slipping and ensures perfect velocity ratio. The chains are used for velocities up to 25 m/s and for power up to 110 kW. (Khurmi, 2005)

*1) Velocity ratio of chain drives*

The velocity ratio of a chain is given by,

$$V.R. = \frac{N_1}{N_2} = \frac{T_2}{T_1}$$

Where,

$N_1$ = Speed of rotation of driver sprocket in rpm; $N_2$ = Speed of rotation of driven sprocket in rpm; $T_1$ = Number of teeth on driver sprocket; and $T_2$ = Number of teeth on driven sprocket.

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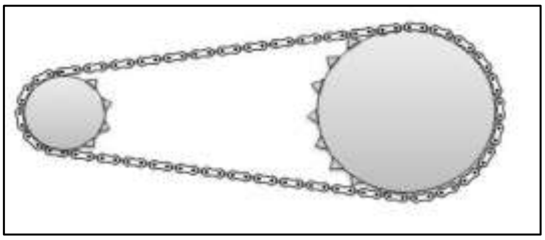

Fig. 1: Chain drive

The average velocity of the chain is given by,

$$V = \frac{\pi D N}{60} = \frac{p T N}{60}$$

Where,
V = Velocity of chain, m/s;
N = Revolution per minutes;
D = Pitch circle diameter of the sprocket, m; and
P = Pitch of the chain, m.

*2) Length of the chain*

A chain drive system connecting the two sprockets is shown in Fig.

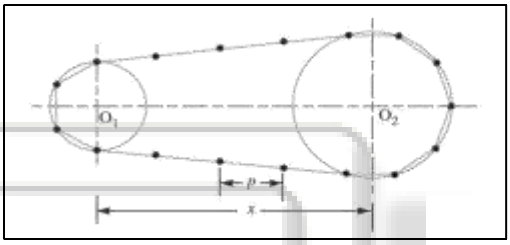


Fig. 2: Length of chain

$$x = \frac{P}{4}\left[K - \frac{T_1+T_2}{2} + \sqrt{\left(K - \frac{T_1+T_2}{2}\right)^2 - 8\left(\frac{T_2-T_1}{2\pi}\right)^2}\right]$$

Where,
T1 = Number of teeth in driver sprocket,
T2 = Number of teeth in driven sprocket,
P = Pitch of the chain, and
x = Centre distance.

$$K = \frac{T_1+T_2}{2} + \frac{2x}{p} + \frac{p}{x}\left(\frac{T_2-T_1}{2\pi}\right)^2$$

*3) Design of chain drive*

The number of links in the chain for system-I was determined by the following relationship,
Centre distance, x = 240 mm
We know that the number of chain link

$$K = \frac{T_1+T_2}{2} + \frac{2x}{P} + \left(\frac{T_1-T_2}{2\times\pi}\right)^2 \times \frac{P}{x}$$

Where,
x = Centre distance between driving and driven sprockets, (mm); T1 = Number of teeth on the first sprocket;
T2 = Number of teeth on the second sprocket; and P = Pitch of the chain, mm.

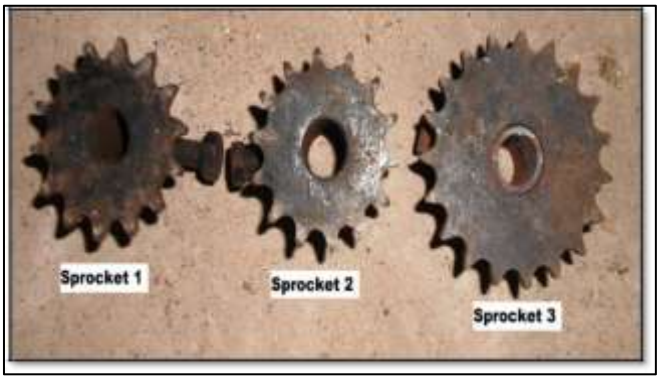


Fig. 3: Transmission system arrangement

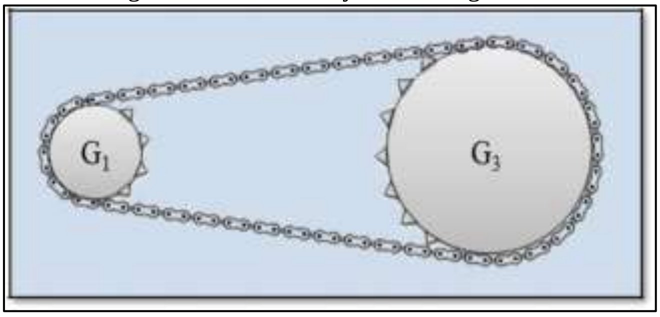


Fig. 4: Chain drive arrangement

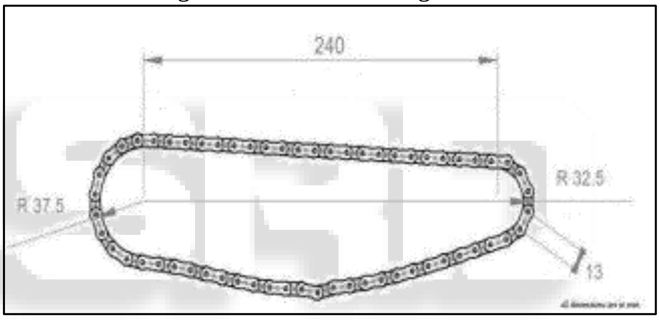


Fig. 5: Design of chain drive

No. of links for chain system – I and III
x = 240 mm
$T_1 = 14$
$T_2 = 19$
p = 13 mm

$$K = \frac{14+19}{2} + \frac{2\times240}{13} + \left(\frac{19-14}{2\pi}\right)^2 \times \frac{13}{240}$$

K = 16.5 + 36.92 + (0.633×0.0542)
K = 54 links
Length of chain for system – I and III
Length of chain = pitch × number of links
Length of chain = 13 × 54
L = 702 mm
No. of links for chain system – $T_2$
x = 240 mm
$T_1 = 14$
$T_2 = 14$
p = 13 mm

$$K = \frac{14+14}{2} + \frac{2\times240}{13} + \left(\frac{14-14}{2\pi}\right)^2 \times \frac{13}{240}$$

K = 14 + 36.92

K = 51 links
Length of chain for system – $T_1$ and $T_3$
Length of chain = pitch × number of links
Length of chain = 13 × 51
L = 663 mm

### B. Types of transmission system

The 3 types of transmission systems arrangements were provided, to get various auger rotational speeds viz. low, medium and high speed. The arrangements are as,

1) Low speed gear: In low speed arrangement, 14 teeth chain sprocket used in input shaft and 19 teeth sprocket in output shaft. If the ground wheel rotates 10 revolutions, the auger rotates 18.75 revolutions.
2) Medium speed gear: In medium speed arrangement, 14 teeth sprocket used both in input and output shaft. If the ground wheel rotates 10 revolutions, the auger will rotate 25.75 revolutions.
3) High speed gear: In high speed arrangement, 19 teeth sprocket used in input shaft and 14 teeth sprocket in output shaft. If the ground wheel rotates 10 revolutions, the auger will rotate 41.00 revolutions.

### C. Development of Auger

Manure supplying spiral auger was provided above the openings in the manure box for continuous feeding of manure on spreading disk.

Chain and sprocket arrangement was provided for rotating the auger. To transmit the power from counter shaft to auger shaft different sprockets were used. There were three types of transmission systems arrangements provided. The free wheel provide the rotation of auger and spreading disk when machine is moving in forward direction and keep stop when machine is moving in reverse direction.

Three types of augers were developed.

*1) Spiral type:*

The diameter of disc was 150 mm which was welded on MS pipe of outer diameter 20 mm, inner diameter 16 mm and length 850 mm in such a way that the disc delivers manure directly on spreading disk through both opening at corners of manure box. The spiral type auger will be shown in Fig. 3.11.

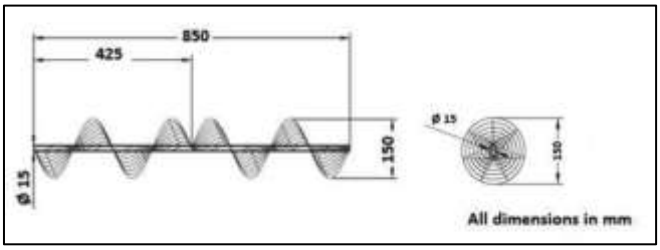


Fig. 6: Schematic view of continuous spiral type auger ($A_1$)

*2) Flat peg type-I:*

The MS flat (70mm×25mm×4mm) were welded on outer surface of MS pipe with outer diameter 20 mm, inner diameter 16 mm and length 850 mm. The total 17 number of pegs were provided. The 4 pegs cover each 360° rotation of auger. The angle between two successive pegs was 90°. The total diameter of the auger was 160 mm. The flat peg type-I auger will be shown in Fig.

*3) Flat peg type-II:*

The MS flat (80mm×15mm×5mm) were welded on outer surface of MS pipe with outer diameter 20mm, inner diameter 16 mm and length 850 mm. The total 33 number of pegs were provided. The 8 pegs cover each 360° rotation of auger. The angle between two successive pegs was 45°. The total diameter of the auger was 180 mm. The flat peg type-II auger will be shown in Fig.

| | Title | Auger A1 | Auger A2 | Auger A3 |
|---|---|---|---|---|
| | Length, mm | 850 | 850 | 850 |
| | Diameter, mm | 150 | 160 | 180 |
| | Material | Cast iron | Cast iron | Cast iron |
| | Weight, kg | 1.8 | 1.2 | 3.1 |
| | No. of pegs in | - | 4 | 8 |
| | each 360° rotation | | | |
| | Angle between | | | |
| | two successive | - | 90° | 45° |
| | pegs, degree | | | |

Table 1: Constructional details of the augers.

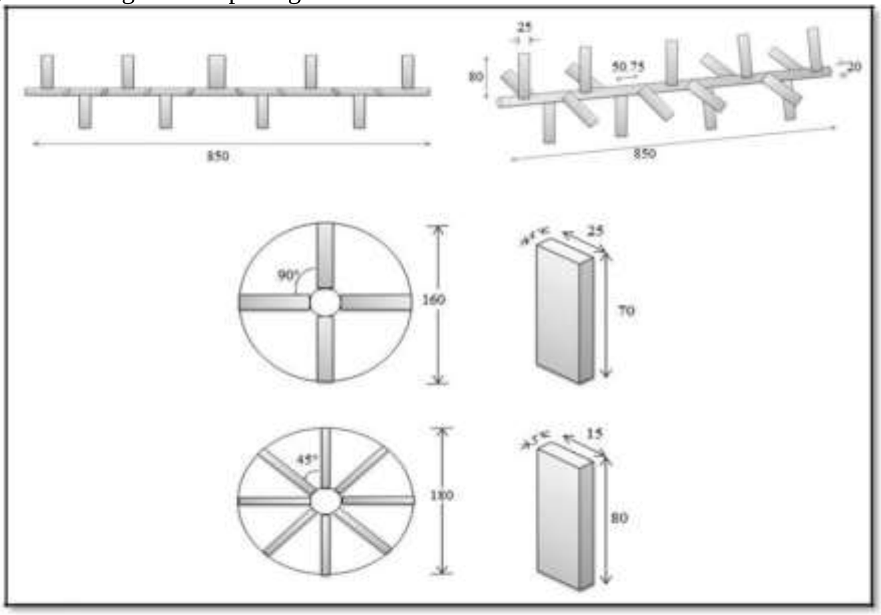


Fig. 7: Schematic view of auger flat peg type-I and flat peg type-II

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Field Conditions
Measurement and calculations
Operating Speed

The speed of operation of applicator was determined in test plots by putting two marks 20 m apart (A & B). The time was recorded with the help of stop watch to travel the distance of 20 m. The speed of operation was calculated in m/s as given below:

$$S = \frac{\text{Distance ,m}}{\text{Time ,s}}$$

Where,
S = Speed of operation, m/s; and
T = Time needed to cover 20 m distance, sec

1) Measuring the pull

The pull was measured by spring type dynamometer. The dynamometer (capacity = 100 kg) was tied on handle of applicator with the help of rope. One hook of the dynamometer was tied on handle and other end with another hitching handle such that the pull is exerted through dynamometer. The observation of pull was recorded during each pass of the applicator for 5 replications after calculating the angle of pull, the draft was determined (Fig.).

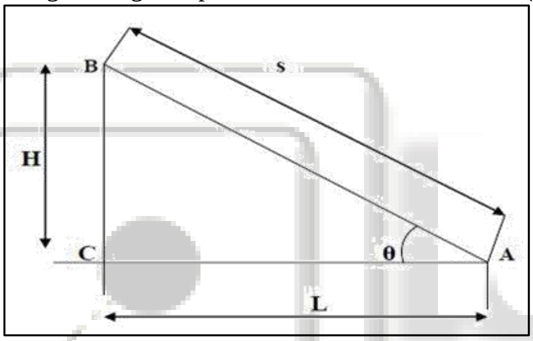


Fig. 8: Measurement of angle of pull

$$\text{Draft } D = P\cos\theta$$

$$\cos\theta = \frac{AC}{AB}$$

Where,
θ = Angle of pull, degree;
H = Height of hitch of the machine from, ground wheel, cm;
L = Horizontal distance between hitch handle and hitch point of machine, cm;
S = Length of rope and dynamometer, cm;
P = Pull, N; and
D = Draft, N.

2) Power requirement

Calculation of power is required to determine the efficient use of manual power. Two men can produce power equal to 0.15 kW. It was the power required to operate the machine by two persons with an average pulling force and speed. It was calculated by using the following formula,

$$\text{Power kW} = \frac{\text{Draft N} \times \text{Speed } (\text{m/sec})}{1000}$$

3) Theoretical field capacity

Theoretical field capacity was measured as per following formula (Bainer, et al., 1960).

$$\text{Theoretical Field capacity ha/h} = \frac{W \times S}{10}$$

Where,
W = Width of implement, m; and
S = Speed of operation, km/h.

Actual field capacity was measured by taking an area of 0.25 ha and measuring the time in actual field condition. It includes turning loss, filling time and break down time.

4) Effective field capacity

There was continuously operated in the field for 0.01 ha to assess its effective coverage. The time required for complete application was recorded and effective field capacity was calculated.

$$\text{Effective Field capacity ha/h} = \frac{A}{T}$$

Where,
A = Actual area covered, ha; and
T = Time required to cover the area, h.

5) Field efficiency

From the effective and theoretical field capacity, the field efficiency was calculated (Bainer, et al. 2005).

$$\text{Field efficiency \%} = \frac{EFC}{TFC} \times 100$$

Where,
FE = Field efficiency (%);
EFC = Effective field capacity (ha/h), and
TFC = Theoretical field capacity (ha/h).
The yield was not taken in account due to limitation of time.

6) Auger revolutions

Auger revolutions were measured with rotates the ground wheel by 10 revolutions. The measurement of auger revolutions is given in Table

| S. No. | No. of teeth in sprocket | | | Revolutions | |
|---|---|---|---|---|---|
| | Input | Output | Ground wheel | Auger | Spreader |
| 1 | 14 | 19 | 10 | 18.75 | 1275 |
| 2 | 14 | 14 | 10 | 25.75 | 1275 |
| 3 | 19 | 14 | 10 | 41.00 | 1275 |

Table 2: The measurement of auger revolutions.

7) Calculation of actual application rate of manure for field operation

The actual manure application rate was determined by using the eqn (Khurmi and Gupta, 2005).

$$AR = \frac{Q \times 10{,}000}{W \times V}$$

Where,
AR = Application rate in kg/ha;
Q = Manure delivery rate in kg/sec;
W = Actual width of application in m; and
V = Forward travel speed in m/sec.

8) Calculation of energy

The energy was calculated by using the following formula,

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Machine energy MJ/ha = $\frac{TIW}{LH} \times HOU \times EE$
Where,
TIW = Total weight of implement, kg
LH = Total useful working life of implement, h
HOU = Hours of useful life of implement, h/ha
= Energy equivalent, MJ/kg

1) FYM applicator

Machine Energy
Total weight = 80 kg
Total useful working life of implement = 240 ×10 = 2400 h
Hours of useful life of implement = 6.62 h/ha
Material used = Mild steel
Energy equivalent for mild steel = 62.7 MJ/kg
Mechanical energy = $\frac{80}{2400} \times 6.60 \times 62.7$
= 13.83 MJ/ha
Operation Energy
2 man = 2×7.46×1.96
= 29.24 MJ/ha
Total energy required = 13.83+29.24
43.07 MJ/ha

2) Manual spreading

Operational energy
1 man = 17.86×1.96
= 35.01 MJ/ha

Energy saving = $\frac{35.01-43.07}{43.07} \times 100$

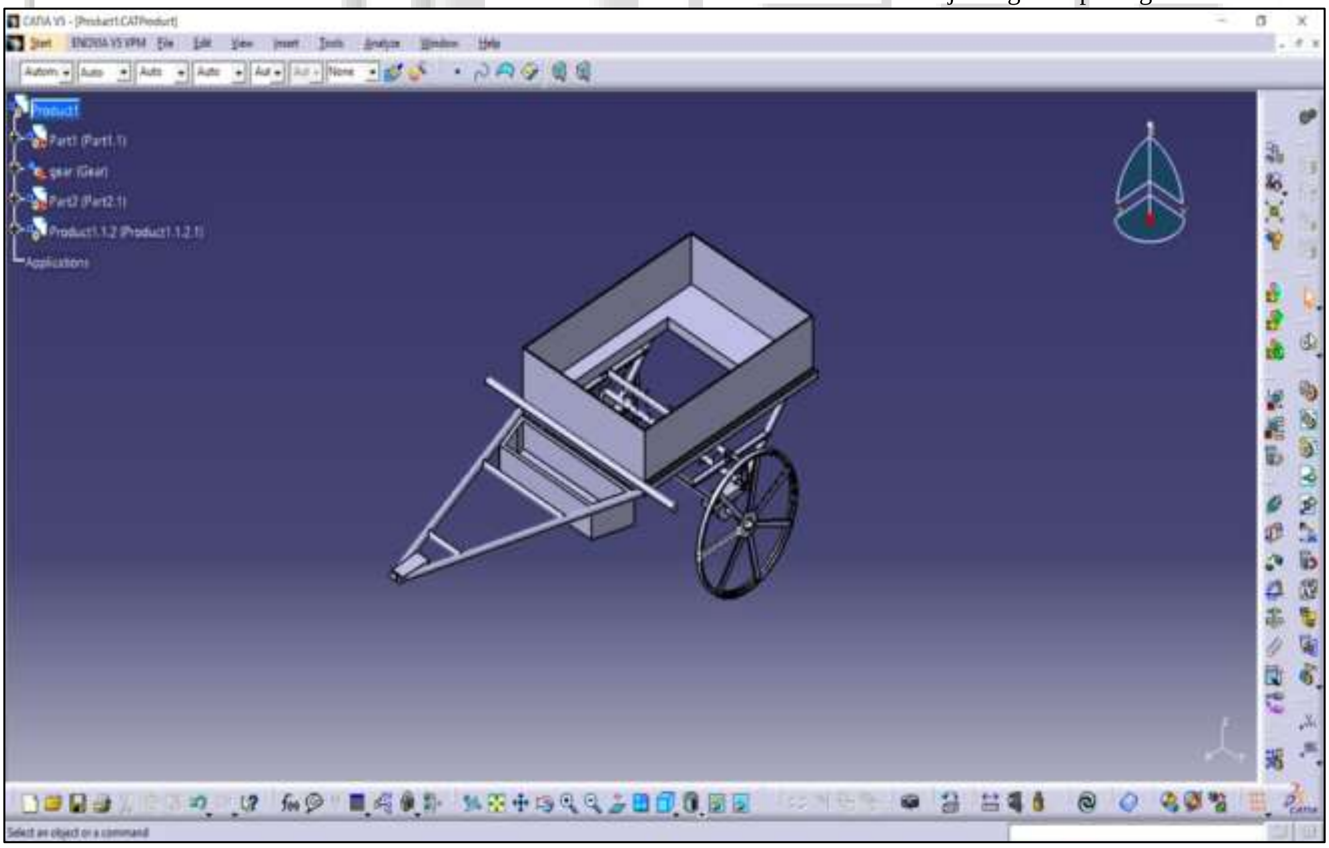
= -18.71 %

9) Chassis

A chassis for two- wheeled bullock cart was modified and adopted for animal drawn manure spreader (fig. 3.1).It was made from a chassis frame of 1800 x 1300 x 500 mm size made of MS pipe of 40 mm inside and 48 mm outside diameter. The.chassis frame was mounted on two £V' shaped side frames made of MS pipes of diameter 48 mm and thickness 4 mm. The adopted axle of 30 mm diameter and 1700 mm long was mounted on the both ends of side frames through pedestal bearing. The distance between the side frames was kept 1000 mm. On the both the ends of the body of chassis two MS sheets of size of 400 x 1200 mm and 2 mm thickness were mounted and in the middle an open space of 1000 x 1000 mm was provided for manure box. A MS platform of size 1000 x 1000 mm was provided to cover open space and convert manure spreader in to cart in ideal period. Two iron wheels of diameter 1000 mm were provided at the both end of axle. The track width of manure spreader was 1700 mm.

10) Manure box

The manure box was made of MS sheet of 2mm thickness. The MS square box section of 12.5 mm provided side support to the box. The box has trapezoidal shaped body for storage and sliding the manure to the rotating auger for spreading. The side frames were made of MS sheet of 2 mm thickness. The side frame gave the strength and support to the manure box. In the bottom side of manure box, peg tooth auger and spiral auger were provided to crush the clods and spread the manure through opening cover uniformly. Provision is made for adjusting the opening area of cover.



3D view of Manure spreader

## III. WORKING

1) Initially Manure is filled in the trolley.
2) After filling trolley is moved to the farming land.
3) Then open locking plate of manure spreader.

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4) As the power is given to mechanism all parts of trolley starts moving.
5) Forward motion of manure is done by Auger & it start's to spread the manure, as the auger start rotating.
6) Centrifugal wheel is used to give direction to manure towards the rotating plate.
7) The whole operation is done simultaneously and its speed is depended on the speed of tractor.

## IV. Advantages of Manure Spreader

8) Less requirement of manure.
9) Can be operated by one person only.
10) Less cost and time required than conventional system.
11) Less man power required.
12) Less power required for process.
13) Nutrition level of land increases.
14) Can be given on rent.
15) Crop quality increases.

## V. Summary

The manure spreader mechanism eliminates the total conventional process. the power of tractor so no need of external power sources this makes machine flexible. A single tractor can run the Manure spreader mechanism. So there is no extra power required. Performance of this spreader on farm field gives effective spreading with low cost &reduction of time.

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