DESIGN AND FABRICATION OF MANURE SPREADER

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Abstract—Manure spreading is the essential operation in a cultivation land for agricultural production. Solid manure is a by-product of cattle, plant waste and other organic waste. To efficiently replace chemical fertilizer with manure, crop producers must be fairly assured of a uniform and controlled rate of manure distribution. Spreading manure accurately enough that farmers can realistically expect full credit for manure nutrients will be critical in the coming years. In the present scenario, manure spreading is a labor-intensive and hectic process. Current solid manure application equipment does not address uniformity and spreading rate control. It is time to take a more sophisticated approach. The trailer used to carry load for the tractor is redesigned to facilitate manure spreading in an eco-friendly manner. The beater has blades welded in a shaft is fixed in the rear end of the trailer. Chain drive is used to transmit power from driver sprocket behind the wheel to driven sprocket at the beater. As the wheel revolves 44 rpm the beater revolves 176 rpm as the transmission ratio of chain drive is 4. A hydraulic cylinder which is operated by tractor is used to lift the base plate for making the manure available for spreading. Instead of lifting the whole setup in a conventional trailer only the base plate is lifted by hydraulic. The load capacity of the trailer is 500kg of cow dung, it can be used for carrying other loads if required.

Index Terms—manure spreader, ground driven, hydraulic lifting, base plate, trailer.

1. INTRODUCTION
Manure is a by-product of cattle, plant waste, and other organic substances. Land, surface water and groundwater can be prevented on the proper application of manure. The crop production can be increased in the timely application of manure at proper quantity. Tons of organic waste that can be utilized as manure is produced in India every year and the land application of those solid waste become a popular method for disposing of them in an eco-friendly manner. Most of the existing spreaders use power take-off from tractor whereas, on the other hand, some use the ground-driven mechanism to run the conveyor mechanism and distributors. The rotation of the wheel is used as a driving part or power source in a ground-driven mechanism. The conveyor is used to make the manure available for spreading blades at the rear end. This is the common working principle of manure spreader.

2. PROBLEMS
The solid manure application equipment does not adequately address uniformity in spreading. The application rate of solid manure was not controlled by the tractor operator or the farmer to a great extent. Most of the manure spreader uses power from power take-off (PTO) from the tractor which is used to run the beater and conveyor arrangement which is not suitable for small scale farmers.

Spreading of manure manually in the field is a labor-intensive and tedious process, unfortunately, there is no commercially available mechanical device in India to spread solid manure uniformly in the farmlands [3]. The uniformity in manure spreading is the main aspect next to workforce requirement in manual spreading because uniformity increases the overall production rate.

3. OBJECTIVES
In accordance with problem definition done before, our main objective is to design and fabrication of manure spreader machine with the following aspects

1. Manure spreader should address uniformity in spreading of solid manure.
2. High degree of control should be in the hand of tractor operator, especially the amount to be manure spreaded.
3. The mechanism used must be simple and efficient.
4. Avoid usage of fossil fuel or external power source of vehicle to operate spreader.
5. Reduce in overall cost of manufacturing manure spreader and cost associated with manure spreading process.
6. To reduce the size of workforce.

4. DESIGN AND CALCULATION

4.1 DESIGN
Figure 1 shows the top view, side view and bottom view of the manure spreader’s design. In the top view at the rear end, it has a beater, then at the front portion, the coupler arrangement is placed to couple the trailer with a tractor. The side view highlights the chain drive arrangement in which the driving sprocket is attached to the beater shaft. The base frame and wheel arrangement are shown in the bottom view are the major load-carrying elements in the trailer. The parts in the manure spreader are listed below.

1. Side plate
2. Base plate
3. Coupler
4. Wheel
4.2 DESIGN CALCULATION

- Leaf Spring

Material = 55Si2Mn90 Steel
Youngs modulus(E) = 2 x 10^8 N/mm²
Length (2L) = 1200mm
Thickness(t) = 6mm
Width (b) = 50mm
Load (W) = 250kg (2500N)
Number of leaf (n) = 7
Number of graduated leaf (n_g) = 4
Number of full leaf (n_f) = 3

Deflection (y) = \(\frac{6WL^3}{nEbt^3}\)
= \(\frac{6 \times 2500 \times 600^3}{7 \times 2 \times 10^5 \times 50 \times 6^3}\)
= 214.28 mm

Bending stress (σ) = \(\frac{6WL}{nbt^2}\)
= \(\frac{6 \times 2500 \times 600}{7 \times 50 \times 6^2}\)
= 714.3 N/mm²

Nib (h) = \(\frac{2WL^3}{nEbt^3}\)
= \(\frac{2 \times 2500 \times 600^3}{7 \times 50 \times 6^3 \times 2 \times 10^5}\)
= 71.42 mm

Load on the clip bolts required to close the gap
\[ P_b = \frac{2n_g n_f P}{n(2n_g + 3n_f)} \]
= 504.2 N

- Calculation for Mass of Manure

Length (l) = 1.524 m
Breath (b) = 1.2192 m
Height (h) = 0.6096 m
Volume = \(l\times b \times h\)
= 1.524 x 1.2192 x 0.6096
= 1.133 m³

Density of cow dung = 420 Kg/m³

Mass of Cow Dung = Volume \times Density
= 1.133 \times 420
= 475 kg

Thus, 475 kg of cow dung can be spreaded by the manure spreader at each load

5. FABRICATION

The base frame is created by welding and side plates are attached to it, a base plate with frame and mild steel plate is made. The trailer is of 1.524 m (6') length, 1.2192 m (4') breath and 0.6096 m (2') height. A hydraulic cylinder is fixed in between base plate and frame. Coupler setup is fixed before the box to couple with the tractor. Leaf spring of 1 m length and 7 leaf is attached below the base frame and shaft is connected to it by u-clamp.

Hub is welded with driving sprocket with 50 teeth and attached to the shaft. Then wheels are attached to the
hub. The base frame along with the side plates and wheel is shown in Figure 2. The beater setup is made of welding blades along with the shaft and attached to the backside of the trailer. Another sprocket of 14 teeth is welded to the overhanging side of the beater shaft and the chain is used to connect sprocket. The overall view of manure spreader is shown in Figure 3.

6. Working
Manure is fed into the trailer when the trailer reaches the farmland the chain is used to connect the two sprockets. As the wheel revolves one revolution the driving sprocket also revolves one revolution, thus the blender setup welded with driven sprocket revolves four times since the transmission ratio is 4 for the chain drive. Revolution of the blender results in the spreading of cow dung from the trailer. The hydraulic system is controlled from the tractor which lifts on given hydraulic fluid and makes the manure available for manure spreading. The hydraulic cylinder lifts the base plate rather than lifting the box setup of the trailer.

6.1 Advantages
- Increase uniformity of manure spreading
- Less time required for spreading
- Less human effort required than the conventional process
- Less waste of the manure
- Eco-friendly mechanism

6.2 Disadvantages
- There is no clutch mechanism to disengage the beater
- Manure filled in the trailer is done manually
- The beater is not removable
- Lubrication is required

7. Result and Discussion
Testing of the spreader in small farmland showed a slight variation in the uniformity of spreading and it was easy to handle in small farmland. The application rate was 5.28 tons per hectare and the application rate was 0.57 hectare per hour.

8. Conclusion
The manure spreader is working with satisfactory conditions. The uniformity and controllability of the manure spreading process were acceptable. This proposed system helps the farmers in spreading the manure in their respective farmland with eco-friendly manure spreader and an independent manner. The cost of manure spreading is greatly reduced by using this proposed system in comparison with conventional existing methods.

References