Design and Fabrication of a Manure Spreader

OSADARE T.[1], ONI, I.O.[2], IKUSIKA, T.T.[3]
[1, 2, 3] *Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic, Ado-Ekiti, Nigeria.*

Abstract- ***A manure spreader that is cheap, affordable, easy to maintain and less laborious to use was developed for use by rural farmers. The machine has the capability of spreading manure over a wide range of area. The machine consists of the main frame, hopper, pulverizer, spreader disc, and handle. All the parts were fabricated from mild steel. Design results of the manure spreaders showed that the mass of the frame was 13.5 kg, mass of spreader disc was determined as 0.466 kg, weight of pulverizer was 2 N, weight of hopper material was 7.2 kg while the capacity of the hopper was determined as 24 kg.***

Indexed Terms- ***Manure spreader, Rural farmers, spreader disc, pulverizer***

I. INTRODUCTION

Manure is a by-product of cows, plant waste, and other organic materials[1]. The proper use of fertilizer helps prevent damage to land, surface water, and groundwater[2]. With the timely application of manure in the right amount, crop productivity can be boosted. Manures are natural or synthetic materials that are added to the soil to provide the necessary nutrients for the plants[3]. They could be natural or synthetic. They create plants, yields, and supplements as part of their labor, and they want to advance at a rate that is much faster than what can be attained by a conventional interaction[4].

According to [5], there are many organ wasting manures available, including farm yard manure, green manures, compost made from crop residues and other farm wastes, vermin compost, oil cakes, and biological wastes including animal bones and slaughterhouse waste. The crop depletes the soil's nutrient reserve by removing a significant amount of plant nutrients[6], notably NPK nutrients, which are projected to be removed from the soil at a rate of 125 kg per ha per year at the current level of crop output[7]. In addition to depleting the soil's nutrient reserves, an excessive reliance on chemical fertilizers and a disregard for the preservation and use of organic sources of nutrients has led to soil health issues that make it difficult to consistently increase agricultural output[8]. The secret to soil fertility and productivity is soil organic matter. However, local farmers face several challenges when it comes to spreading manure. One of the main challenges is the labor-intensive nature of the task. Spreading manure manually requires a significant amount of physical effort and time, especially for larger areas[9]. This can be a challenge for farmers who have limited manpower or resources. Another challenge is the uneven distribution of manure. When spreading manure by hand, it can be difficult to ensure that it is spread evenly across the fields. Uneven distribution can lead to inconsistent fertilization of the soil, affecting crop growth and yield[10]. Additionally, there may be challenges related to the storage and transportation of manure. Local farmers often have limited space to store manure, which can pose logistical challenges[11]. They may also face difficulties in transporting the manure from the storage area to the fields, especially if they don't have access to specialized equipment like manure spreaders[12]. Thus, there is need to provide an affordable and easy-to-use manure spreader to alleviate the problem of local farmers.

II. SOLID MANURE

Solid manure is a crucial resource in agricultural practices, particularly in organic farming and sustainable agriculture[13]. It is composed of livestock excreta mixed with bedding materials such as straw or sawdust[14]. Unlike liquid manure, solid manure has a drier consistency and is often piled or stacked for storage before application to fields[15].

Solid manure can be sourced from various types of livestock, each contributing differently to the

composition and nutrient content of the manure. The primary sources of solid manure include:

i. Cattle:

a. Dairy Cows: Dairy cows are one of the largest producers of solid manure. The manure from dairy operations typically contains a mixture of faeces, urine, and bedding materials like straw or sawdust[16]. Dairy cow manure is rich in nutrients, particularly nitrogen and potassium, and has a relatively high moisture content[17].

b. Beef Cattle: Beef cattle also produce substantial amounts of solid manure. The composition of manure from beef operations can vary depending on the cattle's diet and the type of bedding used[18]. It is often stacked and composted before being applied to fields.

ii. Poultry: Poultry manure, particularly from chickens, is another significant source of solid manure. Poultry litter consists of droppings mixed with bedding materials like wood shavings or straw[16]. Poultry manure is known for its high nitrogen content and is often used as a potent fertilizer in crop production[19].

iii. Swine: While swine operations typically produce more liquid manure, solid manure can still be sourced from swine, particularly when bedding is used in housing systems. Solid swine manure, often mixed with straw or other bedding materials, can be composted and used to improve soil fertility[20].

iv. Sheep and Goats: Sheep and goats produce solid manure that is drier and more compact than that from larger livestock[21]. Their manure is rich in nutrients and is often used in organic farming. Due to its lower moisture content, it is easier to handle and apply[22].

v. Horses: Horse manure, mixed with bedding materials such as straw, wood shavings, or peat moss, is a valuable source of organic matter[23]. It is often composted to reduce the risk of weed seeds and pathogens before being used as fertilizer.

III. MATERIALS AND METHODS

The manure spreader in Figure 4 was developed at the Department of Agricultural and Bio-Environmental Engineering, Federal Polytechnic, Ado-Ekiti, Nigeria. The features of the manure spreader include frame, Hopper, Disc spreader, Pulverizer, and drive wheel.

i. Frame: The frame is made of 75mm ×75mm mild steel angle iron for the petrol engine seat and 75mm × 75mm square pipe for the remaining part of the framework. It is strong enough to withstand all types of loads in working conditions. All other parts of the machine are fixed to the frame using bolts and nuts and by welding operation.

ii. Hopper: The hopper is made of mild steel. The thickness of the plate for the hopper is 2mm, while the length is 667mm × 500mm width the hopper is welded with the frame.

iii. Disc Spreader: The disc is made up of mild steel sheet cut into a circular shape. The thickness of the disc is 2mm, while an angle iron of 70mm × 70mm is welded onto the disc for spreading manure on the farm.

iv. Pulverizer: The pulverizer is made of mild steel sheet cut into cylindrical shape. The thickness of the pulverizer is 2mm while spike of 1cm of different pieces were welded on it using electrode.

v. Drive Wheel: This is the two wheels made 8mm thick flat bar, fitted on an axle for transportation of the machine to the farmland. The wheel is provided with a suitable attachment to transmit the rotary motion.

The design of the manure spreader is based on the following considerations:

i. The manure spreader is simple in design with the use of locally available materials for the fabrication of the component parts.

ii. The ease of fabrication of the component parts with simple joinery methods.

iii. The manure spreader is easy to operate.

iv. Affordability of the manure spreader for small-holder farmers.

The following design calculations were carried out for the machine analysis:

i. Determination of the Volume of Hopper

Volume of the hopper $= {}^{1}/_{3}\, h \quad (A_1 + B_2 + \sqrt{A_1 + B_2})$

where,

h = height of the hopper

A_1 = Area of lower base

A_2 = Area of upper base

The volume of hopper determination is determined as $0.047m^3$

ii. Determination of Capacity of hopper
Mass of material contained in the hopper $= \rho \times V$
where,
$\rho =$ density of material in the hopper
$V =$ Volume of hopper
The capacity of hopper is determined as 24 kg.
iii. Determination of mass of hopper material
$M_H = \mathrm{e}_H \times V_H$
where,
$M_H =$ mass of hopper material
$\mathrm{e}_H =$ density of hopper material
$V_H =$ volume of hopper material
The mass of hopper material is determined as 7.2 kg.
iv. Determination of Mass of the Frame
$M_f = P_f \times V_f$
where,
$M_f =$ mass of the frame (kg)
$P_f =$ density of the frame (kg/m^2)
$V_f =$ volume of the frame (m^3)
The mass of frame is determined as 13.5 kg.
v. Determination of mass of spreader disc
$M_S = P_S \times V_S$
where,
$M_S =$ mass of the spreader
$P_S =$ density of the spreader
$V_S =$ volume of the spreader
The mass of spreader disc is determined as 0.466 kg.
vi. Determination of weight of pulverizer
$M_P = \mathrm{e}_P \times V_P$
$V_P = 2[\frac{\pi d^2}{4} \times t] + [2\frac{\pi d^2}{4} l \times t]$
$W_P = M_P \times 9.8$
where,
$W_P =$ weight of pulverizer
$M_p =$ mass of the pulverizer
$V_P =$ volume of the pulverizer
$\mathrm{e}_P =$ density of pulverizer material
The weight of pulverizer is determined as 2 N.
vii. Determination of the shaft diameter
The material for the shaft is mild steel rod. For a shaft having little or no axial loading, the diameter may be obtained using the ASME code equation [24] given as:
$d^3 = \frac{16}{\pi S_s}\sqrt{(k_b M_b)^2 + (k_t M_t)^2}$
where,
$d =$ diameter of the shaft (m)
$M_b =$ Bending moment (Nm)
$M_t =$ Torsional moment (Nm)
$k_b =$ combined shock and fatigue factor applied to bending moment
$k_t =$ combined shock and fatigue factor applied to torsional moment
$S_s =$ allowable stress $= 40\ Nm^{-2}$ (for shaft with key way)
For rotating shafts, when load is suddenly applied (minor shock) (Khurmi and Gupta, 2005).
A shaft diameter of 30 mm was obtained

IV. FABRICATION OF THE MACHINE

All the parts of the manure spreader were fabricated in the workshop of the Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic, Ado – Ekiti.

The dimension of the hopper was marked and it was cut out using cutting disc attached to the angle grinder and it was assembled by welding using the electrode. The hopper is welded to the frame. A disc spreader of 30-diameter plate was cut out the flat bar was welded on the top of the plate and the top gear was connected to the pipe inside the disc spreader hole. The shaft used was 30 mm diameter which was welded to the gear and pulverizer using the electrode. The top shaft is attached to the bearing and joined with the frame at both ends using a bolt and nut for rotating the pulverizer and pulley.

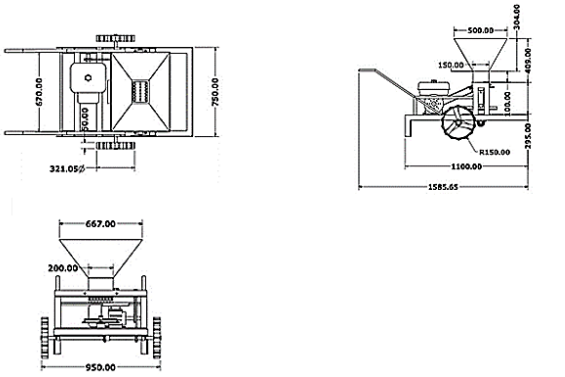


Fig. 1: Orthographic drawing of the Manure Spreader

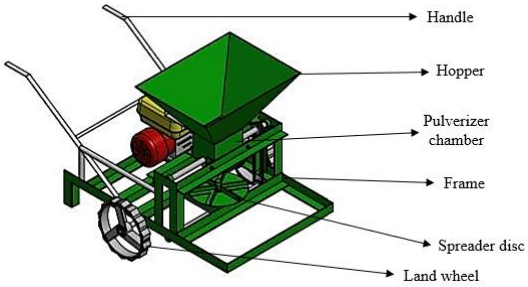
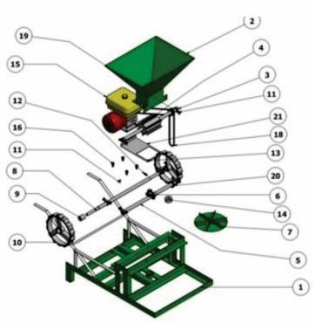


Fig 2: Isometric drawing of the manure spreader



PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Frame	2" AAnle Iron
2	1	Hopper	2mm M/S Plate
3	6	Bearing	Pillow Bearing
4	1	Feed control	30mm Shaft, 2mm M/S Pate and 16mm rod
5	1	Spreader Shaft	30mm shaft
6	1	Gear	Bevel gear
7	1	Disc	1mm M/S Plate
8	1	Wheel shaft	30mm Shaft
9	2	Ball bearing	25mm I.t. Dia.
10	2	Wheel	30mm by 8mm Flat bar
11	12	ISO 4017 - M6 x 20	Hex-Head Bolt
12	4	ISO 4017 - M8 x 25	Hex-Head Bolt
13	15	ISO 8675 - M8 x 1	Hex Nut
14	1	Spreader bearing	25mm
15	1	Prime mover	13 Hp Petol Engine
16	4	DIN 6914 - M12 x 30	Hex-Head Bolt
17	1	ISO 8675 - M10 x 1	Hex Nut
18	2	V-Belt	
19	2	Grooved Pulley1	30mm bore
20	2	Grooved Pulley2	30mm bore
21	1	Upper feed control	

Fig 3: Exploded view of the manure spreader

Fig 4: Photograph of the fabricated manure spreader

Figure 4 shows the photograph of the manure spreader. The drive shaft controls the pulverizer which breaks up the manure into smaller pieces. The spreader disc then throws the manure unto the field.

CONCLUSION

The manure spreader was designed and fabricated in the Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic, Ado-Ekiti. The machine consists of a hopper, which is a large container that holds the manure, a pulverizer that breaks up the manure into smaller pieces, a spreader disc and handle to control the movement of the manure spreader. The design results of the manure spreaders showed that the mass of the frame was determined as 13.5 kg, mass of spreader disc was determined as 0.466 kg, weight of pulverizer was 2 N, weight of hopper material was 7.2 kg while the capacity of the hopper was determined as 24 kg. The manure spreader is portable, easy-to-use, and affordable. It can help to reduce the manual labour required to spread manure, improve fertilizer distribution, and increase crop yields. All parts of the manure spreader were fabricated from mild steel material.

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