Kathmandu University
Journal of Science, Engineering and Technology

Design and fabrication of animal waste cleaning machine

Laxmi Parajuli , Samundra K.C. , Saroj Paudel , Subash Khatri* , and Surakshya Neupane

Department of Mechanical and Automobile Engineering, Tribhuvan University, Institute of Engineering, Pashchimanchal Campus Pokhara – 16, Lamachaur, Nepal.

Abstract

Cleaning is an essential and unavoidable part of life, and cleaning animal shed waste is a time-consuming activity that may be better spent on something more productive. During discussions with dairy farmers in Nepal, it became evident that animal waste collecting equipment was required. One of the primary reasons for this requirement is labor scarcity, which is caused by employees' dislike of picking and collecting animal dung manually. Animal waste cleaning machine provides a strategy for collecting animal dung and cleaning the space without putting people in close contact with the dung. A chain drive mechanism is used in this machine. The dung is collected with the help of picker/rubber pads that are welded to the chain, then dropped into the collector, and the process is repeated. The chain is coupled to a 12V battery-powered dc motor. The machine is cost-effective and saves time by reducing human labor. It may also be utilized as a stand-alone device in remote areas.

Keywords: Dairy farming; Animal dung; Chain drive mechanism; Animal waste cleaning machine; DC motor

1. Introduction

Nepal is a landlocked country with a rich diversity of ethnicities and cultures and agriculture is central to the national economy. The country's agriculture sector is a mix of crops and livestock farming. Livestock farming in Nepal, especially dairy farming alone, contributes a major share of the total Agricultural Gross Domestic Product. Livestock farming is an important agricultural sub-sector in Nepal. According to Central Bureau of Statistics (CBS) data from 2011, livestock accounts for approximately 32 percent of agricultural GDP and 11.5 percent of total country GDP[1]. The raising, slaughtering, processing, and selling of livestock and livestock products employs a large number of people. Cattle are owned by more than 2 million families. Although livestock farming grows at a slower rate than fisheries and cash crops, it contributes more to agricultural GDP overall than fisheries and cash farming. The overall growth rate of cattle is roughly 5.3 percent per year, according to Ministry of Agriculture Development (MoAC) figures (2011/12). In certain parts of Nepal, farmers continue to raise cattle using traditional ways. In order to increase productivity and the overall growth rate of livestock, things need to be more advanced in techniques. Animal dung is a very important source of bio-fertilizer and is also used for the generation of energy in developing countries like Nepal [2].

Ramesh et al., 2018 [3] developed a model of a trash cleaning machine to replace manual work in drainage cleaning. Sirsat et al., 2017 [4] emphasized the design details of the river waste cleaning machine and Dhande et al., 2017 [5] developed the concept of the river cleaning system. In order to contribute in the advancement in livestock farming, there is a need of machine that would do the job much efficiently, economically and much faster than human. By using this animal waste cleaning machine NIF, 2018 [6], one person can clean the cattle animal waste in lesser time and can dump the waste in proper place. This equipment is specifically intended for cleaning livestock farms. This machine is made up of interconnected mechanical components such as bearings and spinning shafts, which are supported by a frame constructed of cast iron pipes, angles, and sheets. Four caster wheels are linked to the frame. The machine's operation necessitates the operator's manual pushing. The machine's structure is rigid and robust to ensure the user's comfort. The purpose of this research is to create a model and prototype of an animal waste collection machine for farmers. The major goal of this research is to develop an automated method to replace the time-consuming and exhausting task of cleaning animal dung.

2. Materials and method

The machine consists of slider riveted to the frame at an angle of 30 degrees as shown in Fig. 1.

The permanent magnet DC motor rotates the chain drive. Bearings and sprockets are used to support the shaft. The bearing is installed on a mild Steel angle frame, and the shaft is linked to it. The frame is welded and has the shape of a machine component that faces the slope. The permanent magnet D.C motor is powered by a 12-volt battery. A small sprocket is coupled to the motor's shaft. On the top shaft, three sprockets are installed. By chain sprocket mechanism, two sprockets are connected to the lower shaft and one extreme position sprocket is attached to the permanent magnet D.C. motor, as illustrated in Fig. 2. The motor can spin at 60 rpm when it's not loaded and 30 rpm when it's loaded. A gear ratio of 0.3:1 is used with a mechanical advantage of 3.23 to provide the torque required to drive the mechanism (picking and collecting). The picker is welded directly to the chain links. The collector tank has a capacity of 20.4 liters. The machine's base is equipped with four caster wheels. With the aid of a picker and a slider, this entire setup is utilized to clean animal dung and collect it into a container. On the rear of the machine, there is a separate handle that may be changed in height as needed. The design of the cleaning machine for fabrication was done using Solidworks2018 and the designed model is shown in Fig. 1.

*Corresponding author. Email: subashkhatri002@gmail.com

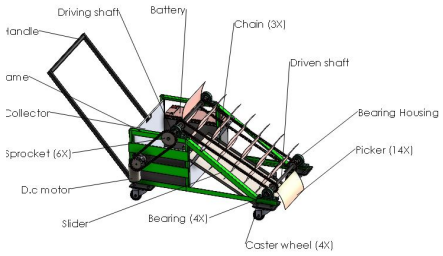

Figure 1: Isometric view of model designed.

Figure 2: Fabricated model.

2.1. Working

The primary goal of this equipment is to extract dung off the floor, collect it in a container, and securely dispose of it. A chain drive system transmits power to the picker. The picker takes dung and other garbage from the floor as it moves, then lifts itself and travels upward. The dung will be dropped into the container when the picker reaches the slider's uppermost point. As a result, dung will be collected from the ground. Four caster wheels make up the machine. When the container is filled, the dung is dumped into the appropriate location. Fig. 2 shows the fabricated model of the ANIMAL WASTE CLEANING MACHINE.

2.2. Components and specification

A frame is a structural framework that holds other components in place. To attach the bearings, T sections are welded to the base frame. With the aid of a chain drive, a solid shaft is used to transport power. A sprocket, sometimes known as a sprocket-wheel, is a toothed wheel that meshes with a chain. Any wheel with radial projections that engage a chain traveling over it is referred to as a sprocket. A ball bearing is a form of rolling-element bearing that relies on balls to keep the bearing races apart. A ball bearing's job is to decrease rotational friction while also supporting radial and axial stresses. They can, however, put up with a slight misalignment of the inner and outer races. The waste is collected in a container. Table 1 shows the detailed component specifications.

2.3. Design calculation

The rated power of motor is 50 W (0.06691 HP) at 12V power supply. No load rpm of motor is 60rpm. No of teeth on the sprocket connected with permanent magnet D.C. motor (Driving gear) are 13 and the no of teeth on a shaft sprocket (Driven gear) are 42. The torque and speed of the motor and the driven shaft were calculated using the formula below:

Power = Current $\times$ Voltage

Current drawn by the motor = Rated Power/Supply voltage = 4.16 A

Table 1: Component specification.

Component	Material	Description
Frame	Mild-steel	Length = 800 mm, Width = 450 mm, Height = 55 mm
Chain	Steel	No of links = 110, Pitch = 12.7 mm
Shaft	Cast Iron	Driving shaft: Length = 650mm, Diameter = 15mm; Driven shaft: Length = 550 mm, Diameter =15 mm
Sprockets	Cast Iron	Small Sprocket(4X): No of tooth = 13, Radius = 17mm; Large Sprocket(1X): No of tooth = 42, Radius = 55 mm
Collector	Tin	Length = 400 mm, Width = 200 mm, Height = 150 mm
Picker	Cast Iron	Length = 300 mm, Width = 140 mm
Slider	Tin	Length = 500 mm, Width = 320 mm
Bearing	Stainless Steel	6202 ball bearing
Wheels	Nylon	diameter = 76.2 mm
Battery	-	12 Volts, 5 Ampere, Lead Acid battery Rechargeable type battery, Works for 2 Hrs.
DC Motor	-	12 Volts, 50 Watts, 60 RPM, Permanent Magnet D.C Motor, Worm Gear Motor.
Bearing Housing	Cast Iron	

And the Torque supplied by the motor calculated as:

$$\text{Torque(T)} = \frac{5252 \times \text{Power (HP)}}{\text{rpm}} = 5.85685 \text{ N m}$$

Torque to the driving shaft is calculated as:

$$\text{Motor torque} \times \frac{\text{No of teeth on driven gear}}{\text{No of teeth on driving gear}}$$

By inserting the aforementioned values into this formula, the torque to the driving shaft is calculated to be 18.92N.

And the driving shaft's speed is computed as follows:

$$\text{Speed of driving shaft} = \text{Motor rpm} \times \frac{\text{No of teeth on driving gear}}{\text{No of teeth on driven gear}} = 18.57 \text{ rpm}$$

3. Results and discussion

To test the machine's effectiveness, 5 kg of animal manure/dung was put on various floors and cleaned by the machine. As shown in Table 2, the machine collected 4.9 kg of dung on concrete, 4.4 kg of stone, and 4 kg of mud floor respectively in one minute. The following formula was used to determine the machine's effectiveness on various floors.

Effectiveness= Amount of dung cleaned / Amount of dung remaining on the floor

As indicated in Table 2, the effectiveness of the machine on a concrete floor is 0.98, while the effectiveness of the machine on a stone floor and a mud floor is 0.88 and 0.8, respectively.

Fig. 3 shows the dung collected by the machine on different types of floors.

The chart shows how the rate of manure cleaning in cattle shed is affected by the type of flooring employed. Stone and mud finished floors have a lower collecting rate than concrete finished floors. This is due to the flat surface of the concrete finished floor, which allows manure to be collected efficiently. However, the uneven surface of stone and mud-finished floors makes it difficult to collect manure.

Table 2: Result acquired on cleaning the various types of floors.

Type of floor	Animal waste collected (kg/min)	Remaining waste on floor (kg)	Effectiveness of machine (%)
Concrete floor	4.9	0.1	98
Stone floor	4.4	0.6	88
Mud floor	4	1	80

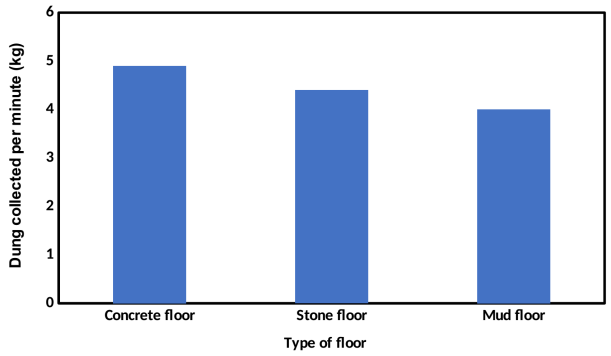

Figure 3: Types of floor vs dung collected per minute (kg).

3.1. Effectiveness

After testing the machine on various types of flooring (as shown in Fig. 3), the effectiveness of the machine for dung collection capacity was estimated(see Table 2).

The graph was created using data from the experiment. As seen in the Fig. 4, the machine does not entirely remove the waste, but a tiny quantity of dung is left behind that may be cleaned with water. Because of the type of floor and surface finish, the machine operates more efficiently on concrete floors than on other surfaces.

3.2. Theoretical and experimental results

The machine was first tested without a load, and the speed of the chain was found to be 5 rotations per minute. Theoretical calculations are based on a 5rpm rotational speed and a torque capability of 18Nm. In addition, it is assumed that each picker carries 350 grams of manure (see Table 3).

When the machine was operated on a concrete floor, the chain speed was measured to be 4 rotations per minute. In one rotation of chain, 1225 grams of dung was collected, as indicated in Table 3.

3.3. Economical validation

The following information was gathered from the small dairy farm:

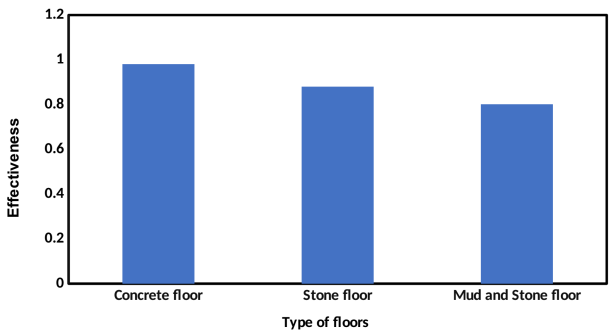

Figure 4: Effectiveness of machine at different sorts of floor.

Table 3: Theoretical and experimental waste collection capacity.

Description	Theoretical calculation	Experimental calculation
Capacity of a picker	350 gm	1225÷4 = 306.25
Total no. of picker	4	4
Dung collection per rotation	350×4 =1400 gm	4900÷4 = 1225 gm
No. of rotation per min	5	4
Total dung collection per min	1400×5 =7000 gm	4900 gm

In a single day, 300kg of manure was produced. To clean up the shed by hand and dump everything in the right place, it costs 800 Nepalese rupees per day and 100 Nepalese rupees per hour. The entire cost of cleaning the shed is 400 Nepalese rupees each day and 12000 Nepalese rupees per month.

As indicated in Table 3, the machine collects 4.9 kg of manure per minute on the concrete floor. Cleaning the shed will take just (300/4.9 = 61.224 minutes), or 1.0204 hours. And the operator's cost will be (Rs. 100 * 1.0204 = Rs.102.04), i.e., about 102 Nepalese rupees a day and 3060.

Nepalese rupees per month.

According to this calculation, the human approach costs 400 Nepalese rupees per day, while the machine approach costs 102 Nepalese rupees per day, and there is a monthly savings of 8940 Nepalese rupees. It's conceivable to argue about the machine's cost-effectiveness.

4. Conclusion

A standalone animal waste cleaning machine with an overall cost of 20,000 Nepalese rupees was designed and constructed to provide easy and effective floor cleaning. This machine can collect dung at a rate of nearly 4.5 kg per minute with a 98 percent efficiency. The machine is compact in weight and has a modular construction. This makes the machine easier to operate. As the test findings showed, this is much more cost-effective than the manual dung management approach. On a monthly basis, it saves almost 6000 Nepalese rupees and 89 hours, omitting power and maintenance costs. Each component was thoroughly evaluated in order to provide the highest possible quality at the lowest feasible cost. Setup and disassembly of each component is very straightforward. The operation of the device does not need any special skills. Because it employs a basic chain drive mechanism, this equipment is ideal for Nepalese rural farmers.

Acknowledgment

We are grateful to the VECTOR-2nd National Technical Festival's organizing committee for financing our work.

References

[1] Livestock Farming, http://www.sasecrtn.edu.np/index.php/en/resources/usefulinfo/how-to-grow-harvest-food-cash-crops/livestock-farming, 10 June 2021.

[2] Cow Dung For Ecofriendly And Sustainable Productive Farming, IJSR - International Journal of Scientific Research(IJSR), IJSR. World Wide Journals,

https://www.worldwidejournals.com/international-journal-of-scientific-research-(IJSR)/article/cow-dung-for-ecofriendly-and-sustainable-productive-farming/NDEzNQ==/?is=1, 10 June 2021.

[3] Ramesh P, Shiyan Varghese J & Manavalan A J, Design and Fabrication of Automatic Trash Removal Machine, (2018).

[4] Sirsat M P M, Khan I A, Jadhav M P V & Date M P T, International Conference on Science and Engineering for Sustainable Development (ICSESD-2017) (www.jit.org.in) Design and fabrication of River Waste Cleaning Machine.

[5] Abhijeet M, Ballade K, Garde V, Lahane M, Boob M & Gobind Singh G, Design & Fabrication of River Cleaning System.

[6] Cow Dung Collecting Machine, National Innovation Foundation-India, https://nif.org.in/innovation/cow-dung-collecting-machine/1101, 10 June 2021.