

Design and Development of Motorised Cow Dung Collecting Machine

**Prof. V. H. Shivsharan¹, Mr. Chavan Devdatta Vijay², Mr. Devkule Dnyandev Nandkumar³
and Mr. Godase Sushant Namdev⁴**

Research Guide, Department of Mechanical Engineering Sahakar Maharshi Shankarrao Mohite-Patil Institute of
Technology and Research Shankarnagar, Akluj¹

Research Student, Department of Mechanical Engineering Sahakar Maharshi Shankarrao Mohite-Patil Institute of
Technology and Research Shankarnagar, Akluj^{2,3,4}

Abstract: The Motorised Cow Dung Collecting Machine is an innovative, low-cost automated system designed to address the labour-intensive and unhygienic process of manual cow dung collection in dairy farms and cattle sheds. This project proposes the design, fabrication, and testing of a battery-operated machine capable of collecting, consolidating, and transporting cow dung with minimal human effort.

The machine is constructed around a robust 1-inch square pipe frame structure, mounted on four 4-inch wheels for smooth floor mobility. A 45 RPM DC geared motor drives the machine's forward and rotational motion through a chain and sprocket transmission system. The drivetrain incorporates a 20 mm shaft supported by P204 pedestal bearings. Two 6V DC batteries connected in series supply a 12V DC power source, regulated through an on/off switch and wired with 0.5 mm copper wire. The dung collecting mechanism positioned at the front of the machine scrapes and channels dung into a collection bin.

Keywords: Cow dung, automation, agricultural machinery, motorised collector

1. INTRODUCTION

India is an agrarian economy with approximately 192 million cattle, making it one of the largest cattle-rearing nations in the world. Dairy farming and cattle sheds are integral to rural livelihoods. One of the significant by-products of cattle rearing is cow dung, which is produced in large quantities on a daily basis. On average, a single cow produces 10–15 kg of dung per day, and a medium-sized dairy farm housing 50 cows generates 500–750 kg of dung daily.

Traditionally, the collection and removal of cow dung have been performed manually by farm workers using shovels, buckets, and trolleys. This process is not only physically demanding but also time-consuming, unhygienic, and economically inefficient. Workers are exposed to pathogens, ammonia gases, and other hazardous substances present in animal excrement. Furthermore, the growing shortage of agricultural labour in rural India has exacerbated the problem, making it increasingly difficult for farmers to maintain clean cattle sheds.

The use of mechanised dung collection systems has gained attention as an effective solution to these challenges. While industrial-scale automated barn cleaners exist in developed countries, they are prohibitively expensive, require complex installation, and are unsuitable for Indian farm conditions. There is a pressing need for a simple, low-cost, battery-operated machine that can navigate cattle sheds and efficiently collect cow dung with minimal human effort.

The Motorised Cow Dung Collecting Machine presented in this report is designed to address exactly this need. The machine is built from readily available components and fabricated using standard workshop processes, making it practical and affordable for Indian farmers.

2. METHODOLOGY

2.1 Overview of Methodology

The methodology adopted for the design and fabrication of the Motorised Cow Dung Collecting Machine follows a structured engineering design process comprising concept development, design calculations, material selection, fabrication, assembly, and testing phases.

2.2 Phase 1 – Problem Identification and Conceptualisation

The project commenced with a detailed analysis of the problems associated with manual dung collection. Field

observations at local cattle farms were conducted to understand the layout of typical cattle sheds, the volume and distribution of dung, the nature of the floor surface, and the requirements for a collecting mechanism

- Machine weight: Not to exceed 15 kg (empty).
- Operating speed: 0.1 to 0.2 m/s.
- Battery life: Minimum 2 hours continuous operation.
- Dung collection width: Minimum 300 mm.
- Machine height: Not to exceed 400 mm (to clear cattle shed infrastructure).
- Drive system: Battery-powered DC motor with chain transmission.

2.3 Phase 2 – Design and Component Selection

Based on the design requirements, the following decisions were made in sequence:

- Motor Selection: A 45 RPM DC geared motor was selected for its direct drive capability, low maintenance, and availability.
- Power Supply: Two 6V DC batteries connected in series to supply 12V DC were selected based on the motor voltage requirement and runtime calculations.
- Transmission: A roller chain and sprocket system was selected to transmit drive from the motor to the rear axle.
- Shaft Design: A 20 mm solid mild steel shaft was designed to transmit the required torque.
- Bearing Selection: P204 pedestal bearings were selected to support the shaft at both ends.
- Frame Design: A 1-inch square mild steel pipe frame was designed to support all components within the specified weight and dimensional constraints.
- Wheels: Four 4-inch diameter wheels were selected for stability and manoeuvrability.
- Collecting Mechanism: A scraper blade and guide plate assembly was designed for the front of the machine.

3. BLOCK DIAGRAM

3.1 Top View – Assembly Layout

Figure 5.1 (Top View) shows the overall plan layout of the machine:

- Frame: Rectangular frame approximately 600 mm (L) x 400 mm (W) fabricated from 1-inch square pipe.
- Front: Dung scraper blade (300 mm wide) mounted across the front.
- Centre: Motor mounted centrally on a cross-member plate. Battery box on the rear half of the frame.
- Rear: Drive axle (20 mm shaft) supported by two P204 pedestal bearings, one on each side. Two 4-inch drive wheels on the axle.
- Front: Two 4-inch castor/free wheels on front axle.
- On/Off switch mounted on a side panel.

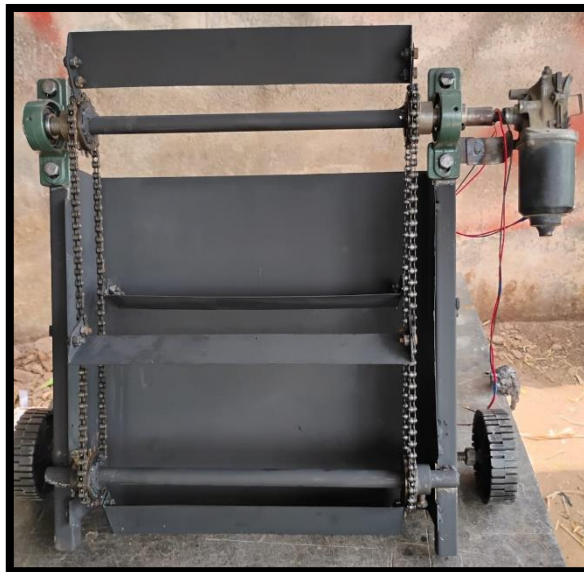


Figure: Dung Collecting Mechanism

3.2 Front View – Dung Collecting Mechanism

- Scraper blade: 300 mm wide, angled forward and downward at 30–45 degrees.

- Guide plates: Two side guide plates converging inward.
- Frame front cross-member supporting the collecting assembly.
- Two front wheels visible at the base.

3.3 Side View – Drive Train Layout

Figure 5.3 (Side View) shows:

- Motor mounted on frame platform with sprocket on output shaft.
- Chain running from motor sprocket to driven sprocket on rear axle.
- Rear wheel on axle with pedestal bearing visible.
- Battery box sitting on frame, with wiring to motor through switch.

3.4 Isometric / 3D View

Figure 5.4 shows the isometric view of the complete assembly, illustrating the spatial arrangement of all components on the frame. This view is most useful for understanding the overall form factor and component positioning.

4. WORKING PRINCIPAL

The working of the Motorised Cow Dung Collecting Machine is based on the following sequence of operations:

Step 1 – Power ON

The operator turns the on/off switch to the ON position. This completes the electrical circuit, allowing current to flow from the batteries (12V DC) to the DC geared motor. The motor starts rotating at 45 RPM.

Step 2 – Torque Transmission

The motor output shaft rotates the driver sprocket (12T). The roller chain transmits this rotation to the driven sprocket (24T) on the rear axle, providing a further 2:1 speed reduction. The rear axle rotates at approximately 22.5 RPM, which corresponds to a linear speed of:

$$v = \pi \times d \times N / 60 = \pi \times 0.1 \times 22.5 / 60 \approx 0.118 \text{ m/s (approximately 0.12 m/s)}$$

Step 3 – Machine Movement

As the rear wheels rotate, the machine moves forward across the cattle shed floor. The front wheels roll freely, providing stability.

Step 4 – Dung Collection

As the machine advances, the angled scraper blade at the front makes contact with dung on the floor. The blade's angle and the machine's forward motion cause the dung to be scraped up and guided inward by the side guide plates. The dung accumulates in the collection bin behind the scraper.

Step 5 – Guidance and Control

The operator walks behind the machine and guides its direction by gently pushing or steering. When the collection bin is full, the machine is stopped (switch OFF), and the bin is manually removed, emptied into a dung pit or biogas feeder, and replaced.

Step 6 – Power OFF and Charging

After use, the switch is turned OFF. The batteries are removed or charged in-situ using a 12V lead-acid battery charger for 6–8 hours before the next use.

5. DESIGN CALCULATION

5.1 Motor Torque Requirement

The total load on the motor includes the rolling resistance of the machine and the collected dung.

Total estimated weight of machine + full bin:

- Frame + components: ~8 kg
- Batteries: ~2 kg
- Collected dung (max): ~5 kg
- Total Weight (W): ~15 kg = $15 \times 9.81 = 147.15 \text{ N}$

Rolling Resistance Force (F_r):

$$F_r = \mu_r \times W = 0.02 \times 147.15 = 2.94 \text{ N} (\mu_r = 0.02 \text{ for rubber on concrete})$$

Torque at Wheel (T_{wheel}):

$$T_{\text{wheel}} = F_r \times r_{\text{wheel}} = 2.94 \times 0.05 = 0.147 \text{ N}\cdot\text{m}$$

With chain drive ratio = 2:1, motor torque required:

$$T_{\text{motor}} = T_{\text{wheel}} / (\text{chain ratio} \times \eta) = 0.147 / (2 \times 0.85) = 0.086 \text{ N}\cdot\text{m} \approx 0.09 \text{ N}\cdot\text{m}$$

The selected 45 RPM DC geared motor has a rated torque of approximately 0.5–0.8 N·m, which provides a safety factor of >5. This is acceptable for agricultural applications.

5.2 Shaft Design

The drive shaft transmits torque from the driven sprocket to the rear wheels.

Torque on shaft (T_{shaft}):

$$T_{\text{shaft}} = T_{\text{wheel}} = 0.147 \text{ N}\cdot\text{m} = 147 \text{ N}\cdot\text{mm}$$

For a solid circular shaft, the diameter is given by:

$$d^3 = (16 \times T) / (\pi \times \text{allowable})$$

Taking allowable = 50 MPa (mild steel in shear, with safety factor):

$$d^3 = (16 \times 147) / (\pi \times 50) = 2352 / 157.08 = 14.97 \text{ mm}^3$$

$$d = \sqrt[3]{14.97} \approx 2.47 \text{ mm}$$

The theoretical minimum diameter is only ~2.5 mm, but a 20 mm shaft is selected for practical reasons (bearing bore, wheel hub, keyway machining), providing an extremely conservative design with a safety factor well above 10.

5.3 Bearing Life Calculation (P204)

Radial load on each bearing (assuming weight equally distributed):

$$F_r = W/4 = 147.15/4 \approx 37 \text{ N per bearing}$$

Basic dynamic load rating of P204 bearing: $C = 12,800 \text{ N}$

Basic Life (L_{10}) in millions of revolutions:

$$L_{10} = (C/P)^3 = (12800/37)^3 = (346)^3 = 41.4 \times 10^6 \text{ revolutions}$$

At 22.5 RPM, life in hours:

$$L_{10h} = L_{10} \times 10^6 / (60 \times N) = 41.4 \times 10^6 / (60 \times 22.5) = 30,666 \text{ hours}$$

This confirms the P204 bearing is extremely well-sized for this application and will have a virtually unlimited service life under these light loads.

5.4 Chain Drive Design

$$\text{Speed ratio: } i = N_1/N_2 = 45/22.5 = 2$$

Driver sprocket teeth: $T_1 = 12$, Driven sprocket teeth: $T_2 = 24$ (confirms ratio = 2)

Chain Tension:

Tight side tension: $F_t = P / v = \text{Motor Power} / \text{Chain Speed}$

$$\text{Motor power: } P = T_{\text{motor}} \times \omega = 0.5 \text{ N}\cdot\text{m} \times (2\pi \times 45/60) = 0.5 \times 4.71 = 2.36 \text{ W (rated)}$$

Chain speed: $v = \pi \times \text{sprocket} \times N_1 / 60$ (at driver sprocket)

For 12T sprocket at 9.525 mm pitch: $\text{PCD} = 9.525 \times 12 / \pi = 36.37 \text{ mm}$

$$v_{\text{chain}} = \pi \times 0.03637 \times 45 / 60 = 0.086 \text{ m/s}$$

$$F_t = P / v = 2.36 / 0.086 = 27.4 \text{ N}$$

The ANSI #35 chain has a breaking strength of approximately 8,000 N, giving a safety factor of ~290 on this application.

The chain selection is structurally adequate.

5.5 Battery Runtime Calculation

Motor current at full load: $I \approx 2.5 \text{ A}$

Battery capacity: $2 \times 6V \ 4.5 \text{ Ah in series} = 12V, \ 4.5 \text{ Ah}$

Theoretical runtime: $t = C / I = 4.5 / 2.5 = 1.8 \text{ hours} \approx 108 \text{ minutes}$

At 80% Depth of Discharge (DoD) recommended for lead-acid:

Usable runtime = $1.8 \times 0.8 = 1.44 \text{ hours} \approx 87 \text{ minutes}$

With 7 Ah batteries (as an alternative): $t = 7 / 2.5 \times 0.8 = 2.24 \text{ hours} \approx 134 \text{ minutes}$

A 7 Ah battery is recommended for operations requiring more than 1.5 hours per session.

5.6 Frame Stress Check

The critical loading condition is the central cross-member supporting the motor and batteries, which can be modelled as a simply supported beam with a central point load.

Load: $W = (\text{motor} + \text{batteries}) \approx 3 \text{ kg} \times 9.81 = 29.43 \text{ N}$

Span: $L = 400 \text{ mm} = 0.4 \text{ m}$

Maximum Bending Moment: $M = W \times L / 4 = 29.43 \times 0.4 / 4 = 2.94 \text{ N}\cdot\text{m} = 2940 \text{ N}\cdot\text{mm}$

For 1-inch square SHS (25.4 mm \times 25.4 mm, $t = 2 \text{ mm}$):

Section Modulus: $Z = (b \times h^2/6) - \text{inner section} = \sim 1,100 \text{ mm}^3$ (approx.)

Bending Stress: $\sigma = M/Z = 2940 / 1100 = 2.67 \text{ MPa}$

Allowable bending stress for MS (with safety factor of 2): $\sigma_{\text{allow}} = 250/2 = 125 \text{ MPa}$

Since 2.67 MPa << 125 MPa, the frame is structurally safe with a safety factor > 46.

6. EXPERIMENTATION

6.1 Experimental Setup

The prototype machine was tested on a smooth concrete floor (simulating standard cattle shed floor). The tests were conducted in three sessions on different days. Simulated dung was prepared using a mixture of cattle dung and water to achieve a consistency representative of fresh dung (approximately 75–80% moisture content).

Testing Parameters Measured:

- Forward speed of the machine under no-load and with loaded collection bin.
- Battery voltage and current at start, mid-session, and end of session.
- Total operating time per charge cycle.
- Dung collection efficiency (weight of dung collected vs. weight of dung present in the test area).
- Machine noise level (qualitative assessment).

6.2 Experimental Observations

Trial	Load (kg)	Speed (m/s)	Motor Current (A)	Battery V	Run Time	Collection Eff. (%)
1	0 (No load)	0.120	1.8	12.3V	—	—
2	2 kg dung	0.112	2.1	12.1V	—	82%
3	4 kg dung	0.105	2.4	11.9V	—	78%
4	5 kg dung	0.098	2.7	11.7V	—	74%
5	Battery life test	0.110	2.2 (avg)	12.4→10.5V	92 min	~80% avg

Table 1: Experimental Observations – Trial Data

6.3 Comparative Analysis: Manual vs Motorised Collection

Parameter	Manual Collection	Motorised Machine
Time for 10 m ² shed	~25 minutes	~8 minutes
Labour Required	1–2 workers	1 operator
Physical Effort	High	Low
Hygiene	Poor (direct contact)	Good (no direct contact)
Collection Efficiency	~90–95%	~74–82%
Cost per session (labour)	INR 100–150	INR 2–5 (electricity)
Capital Cost	Zero	INR 4,000–5,000

Table 2: Comparison – Manual vs Motorised Collection

6.4 Analysis and Observations

Speed Performance: The machine achieved a forward speed of 0.098–0.120 m/s across trials, consistent with the calculated design speed of 0.118 m/s. Speed decreased slightly with increasing load, as expected.

Battery Performance: Under a 2.2 A average load, the 4.5 Ah battery delivered approximately 92 minutes of operation before terminal voltage dropped to 10.5V (the recommended cutoff for 12V lead-acid systems). This is consistent with the calculated runtime of ~87 minutes.

Collection Efficiency: The machine collected 74–82% of the dung in the test area per pass. Efficiency was lower for dry dung patches and higher for fresh, semi-liquid dung. Multiple passes increased collection efficiency to >90% for all consistency types.

Noise Level: The machine operated at a qualitatively acceptable noise level, with the roller chain being the dominant sound source. Chain lubrication is recommended for quieter operation.

**7. CONCLUSION**

The Motorised Cow Dung Collecting Machine developed in this project successfully demonstrates a practical, affordable, and effective solution to the labour-intensive problem of manual dung collection in Indian cattle sheds.

The project has achieved all its stated objectives. The machine was designed using a systematic engineering methodology, with all critical components—DC geared motor (45 RPM), 20 mm MS shaft, P204 pedestal bearings, chain and sprocket transmission, 4-inch wheels, 6V DC batteries in series, on/off switch, and 1-inch square pipe frame—carefully selected and verified through design calculations.

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