Journal of Innovations in Engineering Education
JIEE 2026, Vol. 9, Issue 1.

https://doi.org/10.3126/jiee.v9i1.82593

THAPATHALI CAMPUS
Institute of Engineering
Tribhuvan University

Design, fabrication, and testing of trommel screening machine for fertilizer grading

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ARTICLE INFO

Article history:

Received 31 July 2025
Revised in 5 April 2026
Accepted 22 April 2026

Keywords:

Trommel screen
CAD model
Fabrication
Fertilizer grading
Compost

Abstract

Organic waste management and compost quality are rising concerns in developing nations like Nepal, where compost often lacks uniformity and standard grading. The grading process is usually performed manually, which is time-consuming, inconsistent, and inefficient. This research aimed to model, fabricate, and test a low-cost trommel screening machine that can separate compost based on particle size, ensuring higher quality and better application efficiency. The prototype was developed with locally available materials in the workshop of IOE Thapathali Campus and tested with compost obtained from community waste sites in Rikishi, Bhaktapur. A mean throughput of 90.09 ± 6.20 kg/h, a screening efficiency of 87.56 ± 4.56%, and an average energy cost of 0.0483 ± 0.0058 NRs/kg were shown by the fabricated model. The corresponding 95% confidence ranges were 83.58-96.59 kg/h, 82.77-92.34%, and 0.0422-0.0544 NRs/kg, respectively. The total fabrication cost of the machine was approximately NPR 45,000, significantly lower than commercially available systems. This study concludes that the machine provides a sustainable solution to improve compost quality at the community and municipal levels.

1. Introduction

Organic waste management has become a major environmental and public health concern [1]. It is even more significant in developing countries, where pace of urbanization and limited waste infrastructure have led to growing volumes of biodegradable waste. In Nepal, organic waste accounts for more than 60% of municipal solid waste, making composting one of the most practical and commonly adopted waste management strategies [2]. Yet the agronomic value of compost depends heavily on its quality, particularly particle size uniformity, maturity, and freedom from contaminants, all of which are shaped by how well the material is graded after processing. When grading is inadequate, compost often retains oversized particles and foreign materials that reduce its effectiveness in the field and discourage farmer uptake [3]. Effective grading of compost improves soil aeration and nutrient availability, as well as increases adoption by farmers due to ease of application in the field [4].

Despite these benefits, a technology gap persists at the community level. Most Nepalese community-level composting facilities still rely on manual hand sieving, a method that is slow, inconsistent, and impractical for large-scale operations [5]. While industrial screening technologies such as vibrating screens and disc separators exist, they often fail in decentralized settings. Vibrating screens are prone to screen blinding while handling moist organic feedstock, and disc separators require high capital investment and complex maintenance [6]. Trommel screens offer a suitable mechanical solution to this problem. They are particularly suited to compost processing due to their simple construction, continuous operation, and robustness in handling heterogeneous materials [7][8]. However, existing literature focuses on large-scale industrial units with capacities exceeding 1 t/hr and price points that are prohibitive for small-scale rural cooperatives and municipal labs.

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Compost screening is a critical post-processing step that determines particle size uniformity, contaminant removal, and overall compost quality. Several mechanized screening technologies have been reported in the literature, including vibrating screens, oscillating sieves, disc separators, and rotary drum (trommel) screens [9][10]. Vibrating and oscillating screens are widely used for dry and granular materials. However, studies show that their efficiency decreases significantly when handling moist and heterogeneous compost due to screen blinding and material adhesion [11]. Disc separators offer high throughput but involve complex mechanical arrangements and precise alignment, making them costly and difficult to maintain for small-scale composting operations [12]. In contrast, trommel screens have consistently been identified as more suitable for compost processing because of their simple construction, continuous operation, and better tolerance to variations in moisture content and feed composition [13]. Comparative studies indicate that trommel screens produce more consistent particle size distribution and experience lower clogging rates than vibrating or disc-based systems when processing organic waste [14].

Extensive research has been conducted on the operational performance of trommel screens. The studies have focused on parameters such as drum rotational speed, inclination angle, mesh opening size, feed rate, and compost moisture content [15]. Compost moisture content is one of the most critical parameters influencing screening performance in rotary drum systems. In case the moisture level is too low, the fine particles tend to generate dust and move rapidly through the screen without suitable separation. On the other hand, when the content of moisture is too high, particles tend to cluster and adhere to the screen surface, leading to clogging or screen blinding, which significantly reduces screening efficiency. Several studies have reported that optimal screening performance for compost occurs when moisture content is maintained within the range of 25% - 30%. Optimal screening efficiency is achieved at compost moisture contents between 25% and 30%, drum speeds of 15-55 RPM, and inclination angles of 5°-10° [10]. Within this range, the compost particles retain sufficient cohesiveness to prevent excessive dust formation while remaining loose enough to pass through the mesh openings effectively. Similar findings have been reported in other compost screening studies, where maintaining moisture close to 30% resulted in improved particle flow and reduced screen blockage. Mesh size selection strongly influences product quality and throughput. Smaller mesh openings (2 mm - 3 mm) yield finer compost suitable for horticultural use but are more prone to clogging, while larger openings (4 mm - 5 mm) are commonly used for agricultural applications. Studies also show that excessive feed rates reduce screening efficiency by increasing material bed depth and limiting particle exposure to the screen surface [16]. Most of these investigations are carried out under controlled laboratories or industrial conditions using standardized feedstock, which does not fully represent the highly variable compost characteristics encountered in community-level waste management systems.

To establish a practical benchmark, selected commercially available trommel screening machines with publicly available pricing information and specification data were reviewed in order to provide an explicit market benchmark. A Tongda compound-fertilizer rotary screening machine with 11 kW installed power and a stated capacity of 1-20 t/h, a Greenera MS Trommel screen machine with 10 HP installed power and a nominal capacity of 1 TPH [17], and a Fr Engimech rotary trommel [18] with 7.5 HP installed power and a nominal capacity of 30 TPH were among selected examples. The listed prices approximately correspond to NPR 684,180-714,588, NPR 320,300, and NPR 3,203,000, respectively, based on the Nepal Rastra Bank selling exchange rates on April 2, 2026, considering the midpoint of the Tongda price range, the average listed capital cost for the three chosen commercial trommel units is approximately NPR 1.41 million. The corresponding specific energy consumptions are within 1.05, 7.46, and 0.19 kWh/t, respectively, with an average of roughly 2.90 kWh/t, based on a first-order estimate of rated power divided by nominal throughput [17][18]. This comparison indicates that while stated energy intensity notably drops as machine productivity increases, commercial trommels typically need significantly higher capital investment. These high capital and energy requirements are too large for use by individual farmers, rural cooperatives, and community composting initiatives in developing countries like Nepal. Furthermore, existing studies rarely integrate performance evaluation with fabrication cost, local material availability, energy consumption, and field testing using real compost sourced from community waste sites. In contrast, the present study develops a locally fabricated trommel screening machine with a total cost of approximately NPR 45,000, demonstrating a substantial reduction in capital requirement while maintaining functional performance. This highlights the potential of low-cost, locally manufacturable solutions for decentralized composting systems.

There is a lack of empirical data regarding the performance of sub-critical speed trommels fabricated using workshop-level tools and locally available materials in the context of Nepal, particularly in the Kathmandu Valley. This study addresses this gap by developing and experimentally validating a sub-critical speed trommel screening machine based on a resource-constrained fabrication approach. It establishes one of the first performance benchmarks for locally-adapted trommel systems in the Nepalese agricultural context. This paper details the design, fabrication, and testing of a context-specific, locally fabricated trommel screening machine.

The system is designed using SOLIDWORKS, fabricated with locally available materials using workshop-level tools, and experimentally validated using mature compost. This integrated approach, from design through to field evaluation all done locally, distinguishes this work from prior studies and makes it relevant to the practical constraints faced by composting operations in resource-constrained environments. Specifically, the study aims to design a trommel screening machine for compost grading with appropriate selection of parameters including drum diameter, length, inclination angle, rotational speed, and screen aperture size. A prototype is then fabricated using locally available materials and manufacturing facilities. Furthermore, the study experimentally evaluates key performance indicators including screening efficiency, throughput, energy consumption and capital cost. Ultimately, this work aims to provide a locally-adapted and practically replicable solution to improve compost quality, support decentralized waste management, and promote sustainable farming practices through an accessible technological solution for compost grading.

2. Research methodology

This study employed a sequential approach comprising design, fabrication, and experimental validation of a trommel screening machine. Design parameters were established through literature review and theoretical calculations. The cylindrical drum was designed with specifications shown in Table 1 based on established trommel operating ranges. Critical rotation and other necessary parameters were also calculated theoretically. All the technical specifications were validated through mechanical calculations to ensure safe bearing loads and belt tensions. The detailed steps followed for the study are shown in Figure 1.

The machine was designed using SolidWorks CAD software as presented in Figure 2. The prototype was fabricated entirely from locally available materials using standard workshop processes (cutting, welding, lathe). A mild-steel frame was constructed with cylindrical drum reinforcement using ring stiffeners. Speed reduction was implemented through measured pulley diameters mounted on deep groove ball bearings. All the components were sourced within the Kathmandu Valley and the workshop of IOE Thapathali campus was used in order to establish local fabrication feasibility.

Performance testing was also conducted at IOE Thapathali Campus using mature compost supplied directly from the Rikishi composting facility (Bhaktapur) at 25% moisture content. Six experimental trials were performed with 2 kg batches at fixed conditions. Key performance indicators; throughput, screening efficiency, energy consumption, and fabrication cost; were quantified to assess both technical functionality and economic feasibility. The combination of design optimization, local fabrication, and field-based experimental validation addresses the critical technology gap for decentralized waste management.

3. Materials and methods

3.1. Design basis and technical specifications

Design parameters were selected based on a review of existing literature on rotary drum screening systems. The drum inclination was set to 7°, within the commonly reported range of 5-10° for effective axial material progression and particle stratification [19]. Rotational speed was targeted at 48 RPM, below the calculated critical speed of approximately 59 RPM for the given drum diameter, to ensure stable rotation and prevent centrifugal particle retention as shown in Figure 4. Critical speed was calculated using Equation 1, and speed ratios across the pulley stages were determined using Equation 2 [20].

$$N_c = \frac{30}{\sqrt{R}}\sqrt{\cos\alpha} \tag{1}$$

Where,

N_c : Critical speed of the drum
R : Radius of the drum
α : Angle of inclination of the drum

Given the high rotational speed of the motor, a multi-stage pulley system was implemented, and the speed ratio for each stage was determined. For the first stage pulley drive,

$$\pi D_1 N_1 = \pi D_2 N_2 \tag{2}$$

Where,

D_1 : Diameter of driving pulley
D_2 : Diameter of driven pulley

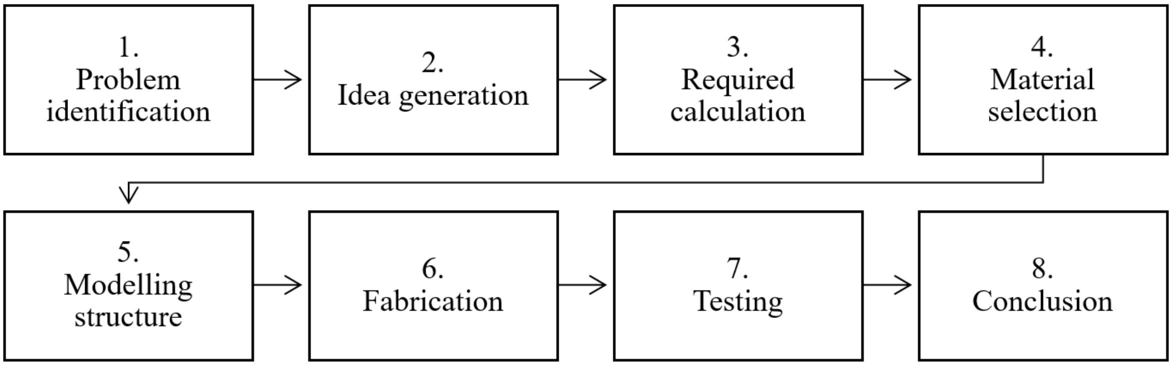

Figure 1: Research methodology

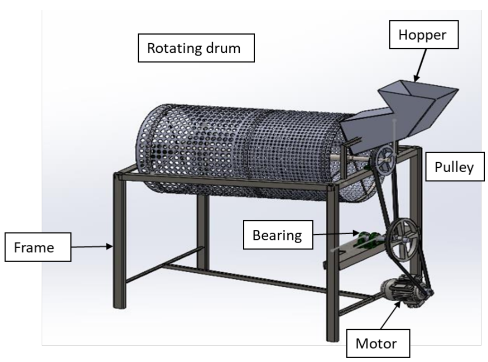

Figure 2: 3D model of trommel screen designed in SolidWorks

N_1 : Rotational speed of driving pulley
N_2 : Rotational speed of driven pulley

To validate the design and ensure safe operating conditions, critical rotational parameters were theoretically determined using the following calculations.

Using the rated motor power and final drum speed, the transmitted torque at the main shaft was calculated using Equation 3. A 25 mm main shaft was selected after the required solid shaft diameter was determined using the torsional design relation in Equation 4 and rounded to the nearest standard size. Equation 5 was used to evaluate the tangential belt force operating on the drum pulley. While the radial load was thought to be primarily controlled by belt pull in conjunction with the supported drum and material weight, the axial force resulting from drum tilt was approximated using Equation 6. This simplified approach is consistent with standard shaft design and rolling-bearing load estimation [21][22].

$$T = \frac{9550P}{N} \tag{3}$$

$$d = \left(\frac{16T}{\pi \tau_{\text{allow}}}\right)^{1/3} \tag{4}$$

$$F_t = \frac{T}{r} \tag{5}$$

$$F_a = W \sin\alpha \tag{6}$$

Where,

T : Transmitted torque (N·m)
P : Power (kW)
N : Rotational speed (rpm)
d : Shaft diameter (mm)
τ_{allow} : Allowable shear stress (MPa)
F_t : Tangential belt force (N)
r : Pulley radius (m)
F_a : Axial force (N)
W : Supported load (N)
α : Drum inclination angle

Using $P = 0.559$ kW, $N = 47.82$ rpm, and $\tau_{\text{allow}} =$ 40 MPa for mild steel, the calculated shaft diameter was approximately 24.2 mm and hence the nearest standard 25 mm shaft was adopted.

Screen aperture sizes of 2 mm and 4 mm were selected based on established compost quality standards and intended end-use applications. The 2 mm aperture produces a fine fraction suitable for potting mixes, seedling nurseries, and precision horticulture, where uniform fine-textured compost is required for optimal seed germination and root development [23]. The 4 mm aperture yields a medium-grade fraction appropriate for general agricultural application, soil amendment, and land restoration, where slightly coarser material is acceptable and higher throughput is prioritized [24]. The oversized fraction (>4 mm) retained in the drum consists primarily of incompletely decomposed organic matter, woody fragments, and foreign materials, which are separated out to prevent contamination of the final product and can be returned for further composting. Together, these two mesh sizes allow the machine to produce two distinct marketable grades of compost from a single pass, improving the versatility and commercial value of the output. The 2-4 mm range also aligns with particle size thresholds commonly referenced in compost quality guidelines for agricultural use in South Asian contexts, making these sizes practically relevant for the Nepali market [25]. Full technical specifications are presented in Table 1.

3.2. Fabrication of trommel prototype

The machine was fabricated entirely from locally available materials in Kathmandu using standard workshop processes including cutting, rolling, welding, and bolting. In the context of this engineering study, locally available materials refer to a deliberate localized procurement strategy. The team sourced all structural and mechanical elements from the existing workshop facility at IOE Thapathali Campus and industrial supply chain within Kathmandu Valley. The frame was constructed from mild steel angle and square sections. The cylindrical drum of 500 mm diameter and 900 mm length was formed by mechanically rolling flat steel strip into a cylinder. It was then reinforced with circular ring stiffeners welded along its length to maintain structural rigidity under load. Two interchangeable stainless-steel mesh screens of 2 mm and 4 mm aperture were mounted on the drum using nut-bolt connections, allowing easy replacement without specialized tools. Stainless steel was selected specifically to resist corrosion from prolonged contact with moist, acidic compost. Speed reduction from the motor to the drum was achieved through a two-stage belt and pulley drive system shown in Figure 3. In the first stage, a 2-inch driver pulley drove a 10-inch driven pulley, reducing motor speed from 1435 RPM to 239.17 RPM. In the second stage, a 2-inch driver pulley drove a 12-inch driven pulley, further reducing speed to 47.82 RPM at the drum shaft, calculated using Equation 2. This final drum speed falls safely below the critical speed of 59 RPM and was experimentally verified using a handheld tachometer. Rotating shafts were supported by deep groove ball bearings (SPF 6205 and SPF 6204). A galvanized sheet-metal hopper facilitated compost feeding, with separate discharge chutes directing each size fraction into distinct collection bins. The principal innovation of our model lies in locally low-cost fabricated construction, two interchangeable 2 mm and 4 mm screens, sub-critical 48 RPM drum speed, and the two-stage pulley reduction system.

3.3. Experimental setup and compost material

After fabrication of the machine, testing of its screening efficiency was done in the Workshop Lab of IOE Thapathali Campus as shown in Figure 4. Compost used in all trials was sourced directly from the Rikishi composting facility from Bhaktapur site. The material was purchased in seal packaging from the facility and used as supplied. Moisture content was 25% as specified on the product packaging. The researchers did not perform any pre-processing, drying, or particle size preparation prior to testing.

During the experimental trials, compost was manually fed into the hopper to synchronize the input with the drum's axial transport velocity, which is governed by the 7° inclination and 48 RPM speed. A batch size of 2 kg was selected to ensure sufficient residence time without overloading the system.

3.4. Performance evaluation and calculation

The performance of the trommel machine was accessed by using key operational parameters considering throughput, screening efficiency, energy consumption, and energy cost per unit mass so as to evaluate both the technical effectiveness and economic feasibility of the system working under real operating conditions. The primary metric used for evaluating the machine's real-world viability is its throughput (T), defined as the mass of compost processed per unit of time and was calculated as a mass flow rate using the following Equation 7 [26] :

$$T = \frac{M}{\Delta t} \times 60 \tag{7}$$

Where:

- T : Throughput (kg/hr)
- M : Mass of the compost batch (2 kg)
- Δt : Measured time from initiation of feeding to final discharge of oversized fraction (minutes)
- 60 : Conversion constant to standardize units to hourly capacity

Screening efficiency is also a key performance indicator in mechanical separation systems, representing the ability of the machine to successfully grade input material through the target mesh aperture while rejecting

Table 1: Trommel screening machine - Technical specification

Components	Specification	Units/Notes
Frame Dimension	950 × 750 × 1100	mm (Mild Steel)
Drum Diameter	500	mm
Drum Length	900	mm
Drum Inclination	7	Degree (°)
Motor	0.75 HP / 1435 RPM	Single-phase AC
Drum Speed	48	RPM
Pulley System	4 pulleys of diameter (2", 10", 12")	Cast Iron
Shaft Diameter	25 mm (main), 20 mm (pulley shaft), 35.4 mm (drum pipe OD)	Mild Steel
Bearings Used	SPF 6205 (2 each), SPF 6204 (power transmission shaft)	Deep groove ball bearings

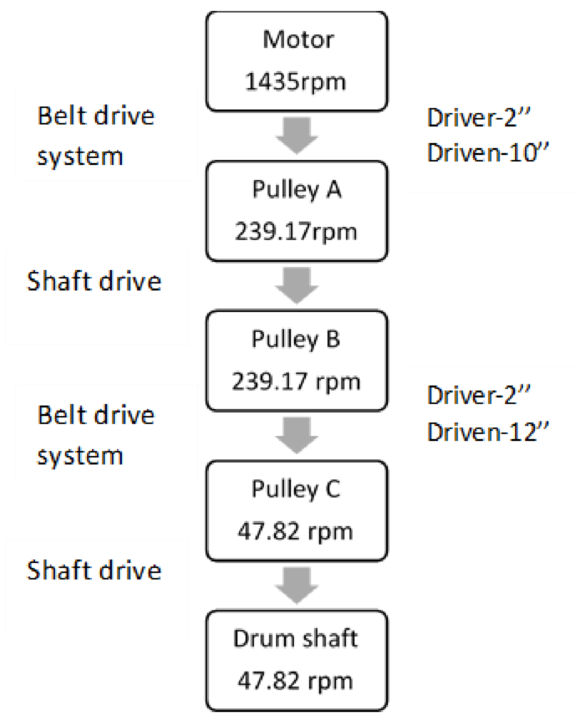

Figure 3: Multi-stage pulley drive system for speed reduction

oversized particles. In trommel screening systems, efficiency is commonly quantified using the oversized rejection method, which evaluates performance based on the mass of material retained in the drum relative to the total feed input [19]. This approach is particularly suitable for field-level evaluations where prior sieve analysis of raw input material is not conducted. In the present study, compost was used directly from sealed commercial packaging without pre-processing, and the particle size distribution of the raw input was therefore not determined prior to testing. Accordingly, screening efficiency was calculated using the following Equation 8 [27][28]

$$\text{Screening Efficiency} = \left[1 - \frac{\text{Oversized fraction}}{\text{Total Input}}\right] \times 100 \quad (8)$$

The oversized fraction consists of incompletely decomposed organic matter, woody fragments, coarse particles that did not pass through either the 2 mm or 4 mm mesh aperture during the trial period. This fraction was collected separately after each trial and weighed using a digital balance. The remaining screened output, comprising the fine (<2 mm) and medium (2-4 mm) fractions, represents the usable graded compost recovered from each trial.

Figure 4: Experimental rotary screening setup

The energy consumed by the trommel screening machine during each trial was determined from the motor power rating and the recorded processing time, as direct electrical measurement using an energy meter was calculated using the following Equation 9 as,

$$E_c = P \times t \tag{9}$$

Where E is the energy consumed (KWh), P is the rated power (kW), and t is the processing time per trial (hr). The motor used in this study has a rated power of 0.75 HP, which is equivalent to 0.559 kW. The operational energy cost was subsequently determined by Equation 10 as,

$$C = E_c \times r \tag{10}$$

Where C is the energy cost (NRs), and r is the prevailing electricity tariff rate of NRs 8.00 per kWh as per the Nepal Electricity Authority (NEA) domestic rate applicable at the time of the study [29].

The 95% confidence interval (CI) for each performance parameter was calculated using the t-distribution, as the sample size was small ($n = 6$). The CI was determined using the following Equation 11 as,

$$CI = \bar{x} \pm \left(t_{\alpha/2,n-1} \times \frac{SD}{\sqrt{n}} \right) \tag{11}$$

Where $\bar{x}$ is the sample mean, SD is the standard deviation, n is the number of trials ($n = 6$), and $t_{\alpha/2,n-1}$ is the critical t-value at 95% confidence level with $n - 1 = 5$ degrees of freedom, equal to 2.571 [30].

Furthermore, a bill of materials (BOM) approach was used to estimate the fabrication cost of the machine based on local material, component available in campus facility, labor, and contingency costs obtained from suppliers and workshops in Kathmandu Valley.

4. Results and discussion

The trommel screening machine was tested to evaluate its performance under consistent moisture conditions using the available compost. The trials provided insight into the system's separation efficiency, throughput, and grading capability across six experimental runs.

4.1. Throughput and operational capacity

The machine was tested across six experimental runs using mature compost to establish a steady-state capacity and its throughput evaluation is presented in Table 2.

The average throughput of 90.09 kg/hr was obtained with an average standard deviation of 6.20 when operated manually at an average feed rate of 2 kg. While the mechanical limits of the 500 mm drum could allow for higher feed rates, the current rate was chosen to prioritize residence time and ensure high screen efficiency.

4.2. Screening efficiency

The screening efficiency of the machine was tested through six trials at a 7° inclination, using 2 kg of material in each run. The results are shown in Table 3.

From the table, it can be seen that the amount of oversized material gradually decreases from 0.37 kg to 0.11 kg over the trials. At the same time, the screening percentage increases from 81.500% to 94.050%, which shows that the performance of the machine improves over time. The operational performance of the trommel prototype across six experimental runs is summarized in Figure 5, showing the measured throughput and screening efficiency alongside their respective standard deviations.

On average, the screening efficiency was found to be 87.56% with an average standard deviation of 4.56%. This indicates that the machine is able to separate the material effectively under these conditions. The gradual improvement in efficiency may be due to smoother material flow and the system becoming more stable as the trials progress.

4.3. Energy consumption calculation

The energy consumption of the machine was analyzed over six trials, and the results are presented in Table 4.

Table 2: Throughput evaluation of the trommel screening machine (2 kg batch per trial)

Trial	Input Mass (kg)	Processing Time (min)	Calculated Throughput (kg/hr)
1	2.0	1.02	98.04
2	2.0	1.45	82.76
3	2.0	1.43	83.92
4	2.0	1.35	88.89
5	2.0	1.25	96.00
6	2.0	1.32	90.91
Average	**2.0**	**1.30**	**90.09**

Table 3: Performance results at 7° inclination (2 kg batches, both meshes)

Trial	Input (kg)	Oversized (kg)	Screening Efficiency (%)
1	2.0	0.37000	81.500
2	2.0	0.32500	84.000
3	2.0	0.26900	86.500
4	2.0	0.23000	88.500
5	2.0	0.18410	90.795
6	2.0	0.11900	94.050
Average	**2.0**	**0.23500**	**87.560**

Table 4: Energy consumption and operational cost per trial

Trial	Time (min)	Time (hr)	Energy (kWh)	Energy Cost (NRs)	Cost per kg (NRs/kg)
1	1.02	0.0170	0.00950	0.076	0.038
2	1.45	0.0242	0.01353	0.108	0.054
3	1.43	0.0238	0.01330	0.106	0.053
4	1.35	0.0225	0.01258	0.101	0.050
5	1.25	0.0208	0.01163	0.093	0.046
6	1.32	0.0220	0.01230	0.098	0.049
Average	**1.303**	**0.0217**	**0.01214**	**0.097**	**0.048**
Std dev	–	–	–	–	**0.006**

It can be seen that the energy consumed per trial varies slightly depending on the processing time, ranging from 0.00950 kWh to 0.01353 kWh. On average, the machine consumes 0.01214 kWh for a 2 kg batch, with a cost NRs. 0.097 per batch or NRs. 0.048 per kg with the standard deviation of 0.0060.

4.4. Cost analysis and fabrication cost

A detailed cost analysis of the developed trommel screening machine was carried out using a bill of materials approach, including material, component, and labor costs based on local market rates. The estimated financial breakdown is presented in Table 5.

Table 5 shows that the machine's total cost to make is NPR 45,000 (about USD 335). The motor, structural frame, gearbox system, and labor to make the parts are the main costs. This relatively low-cost shows that the machine is cheaper than commercial trommel systems, which makes it good for small-scale and community use.

4.5. Overall performance statistics of the developed trommel prototype

The overall performance statistics of the trommel screening machine across six trials are summarized in Table 6.

The working model demonstrated an average throughput of 90.09 ± 6.20 kg/h, a screening efficiency of 87.56 ± 4.56%, and an average energy cost of 0.0483 ± 0.0058

Table 5: Detailed cost breakdown of the developed trommel screening machine

Item	**Cost (NPR)**
Mild-steel frame and base members	7,000
Drum shell and ring stiffeners	6,500
Stainless-steel screens (2 mm and 4 mm)	4,500
0.75 HP single-phase motor	8,500
Pulley-belt transmission system	4,000
Shafts, bearings, and supports	5,000
Hopper and discharge chutes	2,000
Electrical accessories, fasteners, finishing	2,000
Machining, welding, and assembly labor	4,500
Contingency / workshop consumables	1,000
Total estimated fabrication cost	**45,000**

Table 6: Overall performance evaluation of trommel screening machine

Parameter	**Mean ± SD**	**95% CI**	**Unit**
Throughput	90.09 ± 6.20	83.58–96.59	kg/hr
Screening efficiency	87.56 ± 4.56	82.77–92.34	%
Energy cost	0.0483 ± 0.0058	0.0422–0.0544	NRs/kg

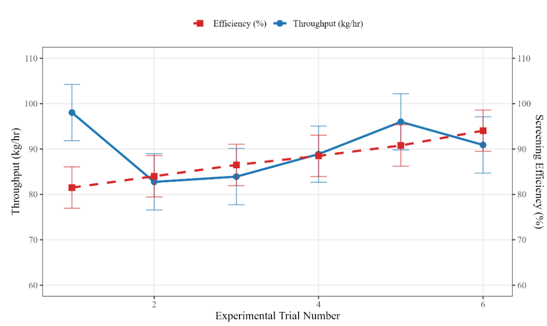

Figure 5: Performance characteristics of trommel screening machine

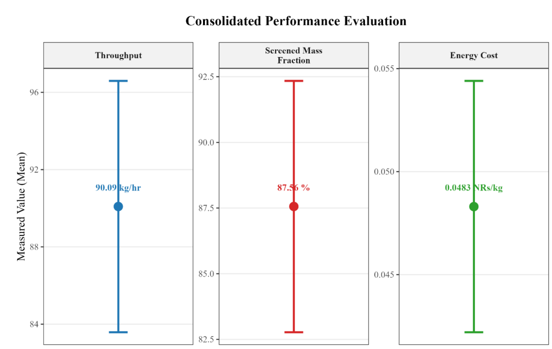

Figure 6: Consolidated performance metrics for the trommel prototype ($n = 6$). Points denote the sample mean; whiskers indicate the 95% confidence interval (CI)

NRs/kg, with corresponding 95% confidence intervals of 83.58–96.59 kg/h, 82.77–92.34%, and 0.0422–0.0544 NRs/kg, respectively. The consolidated performance metrics of the prototype were evaluated to determine system reliability, as shown in Figure 6. The results demonstrate a high degree of repeatability, with all parameters maintaining narrow confidence intervals across the trials.

5. Conclusion

This study designed, fabricated, and tested a trommel screening machine for compost grading using locally available materials at IOE Thapathali Campus, Kathmandu. Six experimental trials were conducted at 48 RPM, 7° inclination, and 25% compost moisture content. With a mean throughput of 90.09 ± 6.20 kg/h, a screening efficiency of 87.56 ± 4.56%, and an average energy cost of 0.0483 ± 0.0058 NRs/kg, the built model proved to be an affordable and technically feasible solution for small-scale compost grading applications. The machine successfully separated compost into fine (< 2 mm) and medium (2–4 mm) grades in a single pass, with oversized material rejected for further composting.

Two limitations were identified. First, heavily clumped compost required manual breaking before feeding. Second, the fixed inclination restricts adaptability to different compost types.

Overall, the prototype confirms that an effective, low-cost compost screening machine can be built and operated at community scale using local workshop facilities. Further work could explore variable drum inclination and automated feeding to further improve performance across different compost characteristics.

Acknowledgements

We would like to express our sincere gratitude to the Institute of Engineering, Thapathali Campus, for providing the funding necessary to complete this project. We also extend our heartfelt thanks to the Department of Industrial Engineering for their continuous guidance and technical support throughout the design, fabrication, and evaluation phases. This project was supported and funded by the Institute of Engineering, Thapathali Campus, under the Department of Industrial Engineering for undergraduate project development.

Authors contribution

Shristi Pandey: Writing – Original Draft Preparation, Methodology, Investigation, Prototype Fabrication, Data Collection and Analysis, Writing – Review and Editing. **Rendira Maharjan:** Prototype Fabrication, Writing, Data Collection. **Krisha Gurung:** Prototype Fabrication, Writing – Review and Editing, Data Collection. **Shreya Dahal:** Prototype Fabrication, Writing, Data Collection. **Rush Pradhan:** Conceptualization, Methodology, Writing – Review and Editing. **Binaya Kumar Lamichhane:** Writing – Original Draft Preparation, Methodology, Supervision, Conceptualization, Project Administration, Validation, Writing – Review and Editing.

Conflict of Interest

The authors declare that they have no competing financial or personal interests that could have influenced the work reported in this paper.

Data Availability

The data supporting the findings of this study are available on request.

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