

Functional Characterization of an Induction Motor-Based Compost Mixer: Evaluating Mixing Uniformity, Ampere Rating, and Dispensing Efficiency

Jerome V. Jocosol

MT, ECT Independent Researcher

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Abstract: The growing need for sustainable composting technologies requires efficient mechanical systems capable of producing consistent, high-quality outputs. This study evaluates the performance of a 220 V, 2200 W induction motor-based compost mixer through three tests: (1) a homogeneity mixture test assessing physical and chemical uniformity; (2) a dispensing efficiency test measuring accuracy and repeatability; and (3) an ampere rating test monitoring current draw under varying loads. Compost samples were analyzed for moisture content, bulk density, pH, and nutrient levels, while current measurements were taken at no load, 3 kg, 4 kg, and 5 kg using descriptive statistics. Results showed highly uniform compost with minimal variability in key parameters, confirming effective blending. Dispensing efficiency ranged from 93.0% to 95.4%, indicating precise and reliable material discharge. Ampere ratings remained stable, averaging 2.29 A (no load) to 2.51 A (5 kg), suggesting efficient power use across loads. These findings demonstrate the mixer's reliability for controlled compost processing and potential suitability for small- to medium-scale operations. Further work should assess long-term performance, adaptability to varied compost materials, and integration of sensors for automated monitoring. This research contributes to advancing smart, energy-efficient composting systems for agricultural and environmental applications.

Keywords: compost mixer, induction motor, functional testing, energy efficiency, homogeneity, dispensing accuracy.

I. Introduction

The growing demand for sustainable agriculture and effective waste management has underscored composting as an efficient means of converting organic waste into valuable soil enhancers (Kielbasa et al., 2018). Mechanical mixers enhance compost quality by improving aeration, accelerating decomposition, and ensuring material uniformity (Wang et al., 2024). Induction motor-based mixers are favored for their durability, low maintenance, and constant torque delivery (Jasim et al., 2021), yet few studies evaluate their performance in terms of output homogeneity, energy use, and dispensing efficiency (Adusei-Bonsu et al., 2021). Uniform mixing promotes consistent microbial activity (Veza et al., 2021), while understanding energy consumption under varying loads informs cost-efficiency. Dispensing performance also influences productivity and labor requirements (Doudkin et al., 2025).

This study addresses these gaps through a functional evaluation of a 220 V, 2200 W induction motor-based mixer using compost as the test medium. It assesses mixing uniformity for a 5 kg load, analyzes power consumption under no load, 3 kg, 4 kg, and 5 kg conditions, and measures dispensing efficiency. Findings will inform composting equipment optimization, energy management strategies, and support small- to medium-scale composting operations.

Statement of the Problem

Efficient mixing is essential in compost preparation to ensure uniform decomposition and nutrient distribution. However, there is limited research evaluating the mixing uniformity and energy performance of low-power induction motor-based mixers when handling organic materials such as compost. With the increasing emphasis on sustainable practices, assessing the performance of a 220V 2200W induction motor-based mixer in terms of compost homogeneity, energy consumption at varying loads (no load, 3kg, 4kg, and 5kg), and dispensing efficiency becomes necessary. This study addresses the following questions:

1. How uniform is the compost mixture output produced by the induction motor-based mixer at a 5kg load?
2. What is the ampere-based power consumption of the mixer at different load conditions (no load, 3kg, 4kg, and 5kg)?
3. How efficient is the machine in dispensing compost after the mixing process?

Hypothesis

The 220V 2200W induction motor-based mixer can achieve acceptable mixing uniformity of compost at a 5kg load, as indicated by a low coefficient of variation, while power consumption, measured in ampere ratings, increases proportionally with load weight (no load, 3kg, 4kg, and 5kg). Furthermore, the mixer is capable of dispensing the compost efficiently, with minimal residual waste and consistent output rate.

Research Objectives

This study evaluates a 220 V, 2200 W induction motor-based mixer for producing uniformly mixed compost at a 5 kg capacity. It measures and compares power consumption under no load, 3 kg, 4 kg, and 5 kg loads, and assesses dispensing efficiency in terms

of discharge smoothness and completeness. The research further examines the relationship between load weight and energy usage, providing performance insights for compost processing applications. 1.4 Significance of the study

II. Literature Review

Functional Characterization of Mixing Machines

Vincent et al. (2021) emphasized that the quality of mixing (QoM) in recycled thermoplastic composites directly affects molding flow behavior and mechanical performance. Using image-based analysis and QoM indicators such as the Index of Scatter (IoS), Bundle Size Distribution (BSD), and Fibre Volume Fraction (FVF) variations, they found that smaller flake sizes and higher mixing speeds improved homogeneity but excessive mixing caused polymer degradation. Limitations in mixer speed and sample size affected reproducibility, prompting recommendations to optimize shear rates and fibre sizes.

Zoellner and Stokke (2021) compared Curved Mixing Structures (CMS) and Double Curved Mixing Structures (DCMS) in microfluidic mixers. DCMS achieved a broader mixing index range but was more sensitive to parameter changes. Reducing channel height and mixer size enhanced mixing by minimizing dead volume and increasing velocity.

Compost Mixers

Bulan et al. (2021) evaluated a drum rotary double helix mixer for composting oil palm fronds using natural inoculum and bokashi at varying speeds. Both methods achieved 75% mass loss and optimal temperatures, meeting compost standards even at lower speeds.

Atienza et al. (2021) developed a dual grinding–mixing machine for vermicomposting, reducing preparation time by two-thirds and increasing monthly production of vermicompost and worm biomass. Shende et al. (2022) designed a solar-powered composting machine that reduced organic waste volume by ~80% and emphasized the role of waste segregation and community participation in compost quality. Al-Yasiry (2022) examined a compost stirring machine, finding that higher speeds and frequent mixing improved fragmentation but increased energy use, while lower speeds enhanced density and reduced fuel consumption.

Homogeneity Mixture

Li et al. (2021) investigated the effect of glucose addition on nitrogen transformation and uniform distribution in compost using ^{15}N -labeled samples. Lower glucose doses enhanced nitrogen homogeneity by promoting microbial assimilation and stabilizing nitrogen within microbial biomass nitrogen (MBN) and soluble organic nitrogen (SON) pools, while high doses reduced uniformity due to osmotic stress. Uniform labeling across nitrogen fractions—indicating full homogeneity was achieved only after 45 days, highlighting the importance of incubation time for consistent nutrient release.

Performance Evaluation of Electric Motors

Electric motors consume a significant portion of industrial energy but are often inefficiently operated due to oversizing, rewinding, or poor load matching (U.S. Department of Energy, 2014). Motors achieve peak efficiency near 75% of rated load, with performance declining sharply below 50%. Common motor load estimation methods include input power measurement, amperage method, and slip method, with the former being most accurate. Efficiency, as defined by NEMA, is the ratio of mechanical output to electrical input and can be calculated using measured load data or manufacturer specifications, noting that rewound motors typically require a 1 to 2 percent efficiency derating. Software tools like ORMEL96 and Motor Master Plus support motor audits, replacement decisions, and energy conservation, especially for units operating over 1,000 hours annually.

Electric motor systems consume about 60 percent of global industrial electricity and nearly 70 percent of total industrial demand, making efficiency optimization essential (Eichhammer & Fleiter, 2012). System level improvements, rather than focusing only on individual components, can yield 9 to 13 percent electricity savings with short payback periods. However, adoption is limited by high upfront costs, limited capital, and managerial barriers. Policies such as Minimum Energy Performance Standards (MEPS) promote high efficiency motor adoption, while integrated frameworks in countries like China and Brazil combine system optimization, capacity development, and auditing schemes to further enhance industrial energy efficiency.

Szénásy and Csikor (2024) optimized induction motor performance through design and control strategies, using controlled drive tests and finite element simulations. They found that part load efficiency improves by adjusting voltage and slip to real time torque demands, and that double cage rotor designs shift the torque slip curve for higher starting torque and efficiency. Their results highlight the value of combining motor design optimization with intelligent control for industrial and electric vehicle applications.

Goman et al. (2020) compared electric motors in fixed speed centrifugal pump applications, including IE3 and IE4 squirrel cage induction motors and IE4 permanent magnet induction motors (PMIMs). Using manufacturer data, pump equations, and statistical modeling, they found that IE classification alone does not ensure minimal energy use. IE4 PMIMs can consume more energy than IE3 or IE4 squirrel cage motors under partial load, despite higher nominal efficiency. They also noted PMIMs' higher costs, limited starting capability, and environmental impact from rare earth materials, recommending motor selection based on actual load cycles, lifecycle costs, and ecological considerations.

Dispensing Efficiency

Takase et al. (2022) evaluated robotic dispensing systems integrating Drug Station®, Mini DimeRo®, and Hp-PORIMS® technologies. Implementation reduced prevented errors from 0.204% to 0.044% and unprevented errors from 0.015% to 0.002% ($p < 0.001$), nearly eliminating serious dosage or drug errors. Median dispensing time dropped from 60 to 23 seconds, improving efficiency. The study demonstrates that well-integrated robotic systems can enhance safety, speed, and workflow in pharmaceutical services.

Mixing Load and Energy Consumption

Silva et al. (2020) used ATPDraw simulations to assess how mixed nonlinear loads (e.g., LED lighting, TVs, inverter appliances) affect power quality and billing under no sinusoidal conditions, finding that even small devices can cause significant harmonic distortion and billing errors. Pedersen et al. (2008) developed a statistical load prediction method for heat and electricity demand in buildings, enabling more accurate system design through peak load forecasting, load profiles, and total energy use estimation. Ratnikov et al. (2021) modeled energy use in centrifugal-blade mixers, identifying flowability as a key factor in mixing efficiency and proposing optimization strategies to cut energy consumption, particularly in compost systems. Vadasarukkai and Gagnon (2017) showed that lower mixing intensities in water treatment can achieve similar DOM removal as higher ones, while producing more efficient floc structures and reducing unnecessary energy use.

Coefficient of Variation (CV)

Jalilibal et al. (2021) reviewed 71 studies (2007–2021) on using the coefficient of variation in statistical process monitoring, particularly when mean and variance are interdependent. They identified scenarios where CV outperforms standard deviation monitoring and highlighted research gaps for future work.

Trend Analysis

Lutz et al. (2001) analyzed global population projections, testing how fertility–life expectancy correlations, autocorrelation, and baseline errors influence outcomes. They found an 85–86% probability that population will peak before 2100, with interregional correlation shifts affecting prediction intervals more than medians. Trend assumption uncertainties had greater impact than baseline errors, reinforcing the likelihood of long-term population stabilization.

III. Methodology**Research design**

This study employs a quantitative experimental research design to evaluate the performance of a 220V 2200W induction motor-based mixer using compost as the test load. The focus is on assessing mixing uniformity, power consumption, and dispensing efficiency across different loads (no load, 3kg, 4kg, and 5kg). Mixing uniformity will be measured using the coefficient of variation (CV), while power consumption will be recorded in ampere ratings using a clamp meter. Dispensing efficiency will be evaluated based on the percentage of material discharged and the time taken to fully dispense the compost. Each load condition will be tested in three trials, maintaining constant speed and mixing duration. Statistical tools such as mean, standard deviation, CV, and trend analysis will be used to interpret results.

Procedures**Homogeneity Mixture Test**

This test assessed compost uniformity by measuring moisture (30–60%), bulk density (0.3–0.8 g/cm³), macro-nutrients (N: 0.1–0.25%, P: 0.05–0.2%, K: 0.08–2.0%), and pH (5.5–8.5). Clean sampling tools were prepared, and composite samples were taken from at least three points and depths. Samples were sealed, labeled, and tested, with averages, standard deviations, and CV values calculated. A lower CV indicated better mixing consistency and compost quality.

Dispensing Efficiency Test

The dispensing system's accuracy and power use were evaluated with 3 kg, 4 kg, and 5 kg compost loads. Actual discharged weights were recorded along with motor ampere draw and dispensing time. Average outputs, current consumption, and efficiency percentages were computed and tabulated to assess performance under varying loads.

Ampere Rating Test

A 220V, 2200W induction motor's current draw was measured under no load and with 3 kg, 4 kg, and 5 kg loads, using an ammeter. Each condition was tested thrice, and mean current values were calculated to analyze load responsiveness and operational efficiency.

Data Analysis

Homogeneity was evaluated using CV, with lower values indicating uniform mixtures. Dispensing efficiency was determined by comparing actual and expected outputs, while trend analysis examined performance consistency. Ampere data were averaged for

each load to assess motor stability. Data were presented in tables/graphs, and reliability was ensured through repeated trials and descriptive statistics.

Sampling Methods

Purposive sampling selected compost batches with uniform composition and moisture. Three samples were tested for each load (3 kg, 4 kg, 5 kg) and no-load condition, ensuring consistent comparisons.

Materials

A 220V, 2200W induction motor-based mixer processed 5 kg compost batches. Power was measured with a clamp meter, weights with a digital scale, and samples collected in plastic cups. A compost bin was used for mixing/dispensing, and a soil-integrated sensor monitored compost parameters (see Table 1).

Table 1. List of Materials Used

No.		Material					Description
1		Induction Mixer			220V, 2200W motor-based mixing machine		
2		Compost				5 kg total load used for testing	
3		Clamp Meter				Measures power consumption in amperes	
4		Compost Bin				Container for mixing and dispensing trials	
5		Weighing Scale			For measuring loads (no load, 3kg, 4kg, 5kg)		
6		Plastic Cups				For sample collection during mixing tests	
7		Soil-Integrated Sensor			For monitoring pH, moisture, and NPK levels		

Experimental Setup

The experiment assessed the performance of a 220V 2200W induction motor-based compost mixer through three tests. The homogeneity test involved collecting ten compost samples post-mixing to evaluate uniformity in mass and consistency. For ampere rating, a clamp meter measured current under varying loads (no load, 3 kg, 4 kg, and 5 kg) across multiple trials. The dispensing efficiency test observed the speed and completeness of material discharge at each load level to assess output consistency.

Homogeneity Mixture Setup

For the homogeneity test, the mixed compost was divided into ten samples, each placed in separate cups. The physical parameters, including bulk density, were measured, and an integrated soil sensor was used to assess the physicochemical properties (e.g.,

moisture, temperature, pH) of all ten samples. Figures 1 and 2 illustrate the sample preparation and measurement setup for the homogeneity test.



Figure 1 Samples during homogeneity mixtures test



Figure 2 Individual Compost Parameters Reading Using the Soil Integrated Sensor

During the ampere rating test, compost loads of 0 kg (no load), 3 kg, 4 kg, and 5 kg were placed into the mixing chamber. A clamp meter was connected to the 220V power line to measure the current draw for each load across multiple trials. This setup helped determine the motor's power consumption relative to different mixing demands. The configuration for this test is shown in Figure 3.



Figure 3 Setup During the Ampere Rating Test

For the dispensing efficiency test, the mixer was manually discharged across multiple trials using compost loads of 3 kg, 4 kg, and 5 kg. The actual dispensed weight (in kilograms) was recorded and compared with the input load to calculate the percentage efficiency of material output. The setup for this test is depicted in Figure 4.



Figure 4 Dispensing Test Set up

IV. Results and Discussion

Homogeneity Mixture Test Results

Ten random samples of compost processed by the 220 V, 2200 W mixer showed highly uniform physical and chemical properties (Table 1). Sample masses (0.400–0.405 kg) and moisture content (avg. 32.3%) were consistent and within the optimal microbial activity range. Bulk density (0.615–0.623 g/cm³, CV = 0.448%) indicated even particle distribution and adequate porosity. Nutrient levels—nitrogen (0.18–0.21%, CV = 5.85%), phosphorus (1.15–1.44%, CV = 7.67%), and potassium (0.19–0.21%, CV = 2.61%)—showed minimal variation. pH values (6.5–7.2, avg. 6.81) remained within the ideal range for compost stability. These results confirm the mixer’s capability to produce a homogeneous, nutritionally balanced compost mixture suitable for efficient microbial activity.

Table 1. Homogeneity Mixture Test Results

Samples	Moisture/ Humidity (30- 60 %)	Bulk Density 0.3–0.8 kg/m ³	Nitrogen 0.1% – 0.25%	Phosphorus 0.05% to 0.2%	Potassium 0.08 to 2.0%	Acidity (5.5 – 8.5)
1	29	0.61	0.615	0.21	1.44	6.7
2	31	0.63	0.616	0.21	1.37	6.7
3	33	0.60	0.616	0.18	1.15	6.7
4	35	0.62	0.617	0.20	1.29	6.7
5	30	0.64	0.618	0.20	1.21	6.5
6	33	0.63	0.619	0.21	1.29	7.2
7	36	0.62	0.620	0.19	1.38	6.9
8	34	0.61	0.621	0.19	1.24	6.7
9	30	0.60	0.622	0.20	1.33	6.8
10	32	0.62	0.623	0.19	1.15	6.7
Average	32.3	0.62	0.619	0.204	1.289	6.81
CV (%)		0.78	0.448	5.85	7.67	2.61

Source: Philippine Agricultural Engineering Standards (PAES). (2011). PNS/PAES 258:2011 – Agricultural machinery: Manure shredder and mixer – Specifications. Bureau of Agriculture and Fisheries Standards

Dispensing Efficiency Test Results

The dispensing functionality test revealed consistent performance across all three trials. Output values closely matched their respective input weights, with minor deviations that fall within acceptable tolerances. As shown in Table 2, both the output weight and the dispensing time increased proportionally with the load size, demonstrating a predictable and linear dispensing behavior. These trends support the reliability of the system’s automated function.

Table 2. Dispensing Functionality Test Results

Trial	Output (Kg)			Recorded Time (Seconds)			Recorded Time Average (Seconds)
	3	4	5				
1	2.75	2.85	2.80	11.5	11.1	11.7	11.43
2	3.70	3.74	3.72	24.4	25.7	25.4	25.17
3	4.75	4.80	4.76	35.3	35.7	35.5	35.5

Source: Rhodes, J. A. M., McCarthy, B. C., & Scott, A. C. (2022). Automated dispensing cabinet functionality to reduce inventory discrepancies. *Hospital Pharmacy*, 57(4), 526–531. <https://doi.org/10.1177/00185787211061380>.

Dispensing efficiency, shown in Table 3, ranged from 93.00% to 95.4%, with the highest performance observed at the 5 kg load. These results demonstrate that the system maintains high accuracy across varying load conditions. A trend analysis of ampere

ratings indicates a gradual, expected rise in current draw (from 2.37 A to 2.53 A), further validating the motor's stable response to increasing load demands.

Table 3. Dispensing Test Results (Average and Efficiency)

Trials	Output (Kg)				Ampere Rating (Ampere)				Efficiency Rate
	3	4	5	Average				Average	
1	2.75	2.85	2.80	2.80	2.39	2.37	2.37	2.80	93.33 %
2	3.70	3.74	3.72	3.72	2.48	2.45	2.46	3.72	93 %
3	4.75	4.80	4.76	4.77	2.49	2.51	2.53	4.77	95.4%

Source: Rhodes, J. A. M., McCarthy, B. C., & Scott, A. C. (2022). Automated dispensing cabinet functionality to reduce inventory discrepancies. *Hospital Pharmacy*, 57(4), 526–531. <https://doi.org/10.1177/00185787211061380>.

Overall, the observed trends both in mechanical output and electrical performance highlight the mixer's consistent functionality, precise material handling, and load-responsive energy consumption.

Ampere Rating Test Results

The ampere rating test aimed to evaluate the electrical current consumption of the mixer under different load conditions no load, 3 kg, 4 kg, and 5 kg over a consistent operation time of 10 minutes per trial. The data, analyzed using descriptive statistics (mean or average), revealed a clear trend of increasing ampere consumption as the load increased.

As shown in Table 4, the average ampere ratings recorded were 2.29 A for no load, 2.37 A for 3 kg, 2.46 A for 4 kg, and 2.51 A for 5 kg. This gradual increase in current draw corresponds logically with the increasing mechanical effort required to mix heavier loads. The small incremental changes in current across trials also reflect the system's stable and consistent electrical performance.

Table 4 Ampere Rating Test Results

Trial	Time (mins)	Capacity (Amperes)			
		No Load	3 kg	4 kg	5 kg
1	10	2.30 A	2.39	2.48	2.49
2	10	2.29 A	2.37	2.45	2.51
3	10	2.29 A	2.35	2.46	2.53
Average:		2.29 A	2.37	2.46	2.51

Source: Thongsong, S., Prasertsit, K., Photaworn, S., & Khongprom, P. (2025, July). Hydrodynamic and mixing behavior of KSM and LSM static mixers based on CFD simulation. *Iranian Journal of Science and Technology, Transactions of Mechanical Engineering*. <https://doi.org/10.1007/s40997-025-00885-z>.

These findings support the mixer's functional reliability and operational efficiency. The use of average values in this context highlights the mixer's predictable power behavior under varying load conditions, an important consideration for long-term energy planning and equipment stress analysis.

Implication of Findings

These findings confirm that the developed system can meet key performance standards for compost production and distribution. The uniformity in output ensures a high-quality compost product, critical for promoting microbial activity and effective decomposition. Consistent energy consumption also implies cost-effectiveness and suitability for small to medium-scale composting operations. Overall, the system presents a practical solution for improving compost processing in agricultural or environmental management applications.

V. Conclusion

The evaluation of the compost mixer's performance across homogeneity, dispensing efficiency, and ampere rating tests demonstrates the system's operational reliability and effectiveness. The homogeneity test confirmed that the mixer consistently produced uniform compost with minimal variation in moisture content, bulk density, nutrient distribution, and pH indicating its capability to meet optimal composting conditions. In the dispensing efficiency test, output weights closely aligned with input loads, achieving efficiency rates between 93.00% and 95.4%, and showing consistent, linear dispensing behavior. Ampere consumption increased slightly with load size, yet remained within a stable range, indicating reliable electrical performance.

The ampere rating test further verified that current draw rose predictably with increasing loads, from 2.29 A (no load) to 2.51 A (5 kg load). The use of descriptive statistics (mean ampere ratings) emphasized the system's consistent electrical demand, aligning with its mechanical workload. Together, these findings confirm that the compost mixer is efficient, electrically stable, and capable of delivering consistent compost quality and output under varying operational loads making it suitable for sustained use in composting systems.

VI. Recommendations

Based on the results of the homogeneity mixture test, dispensing efficiency test, and ampere rating test, it is recommended to further strengthen the functional characterization of the 220V 2200W induction motor-based mixer. The system has shown high operational reliability and mixing performance; however, extended evaluation under varying operational and environmental conditions will help refine its functionality and applicability.

Perform dynamic load testing to assess the mixer's performance and energy consumption across different compost textures, moisture levels, and bulk densities, aiming to optimize power usage and uniformity.

Expand functional trials to include longer continuous operations and real-world usage scenarios to evaluate wear resistance, motor response, and consistency in mixing and dispensing outputs over time.

VII. Acknowledgement

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