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Analysis of BLDC Motor Functionality for Noise Reduction

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Abstract: *Mixer grinders are widely used household appliances, but conventional models using universal motors often face issues such as high noise, lower efficiency, and frequent maintenance due to brush wear. To overcome these limitations, the use of Brushless DC (BLDC) motors has gained significant attention in recent years. This paper reviews the application of BLDC motors in mixer grinders with a focus on achieving low noise operation and high energy efficiency. BLDC motors operate without brushes, which reduces mechanical losses, minimizes noise, and increases the overall lifespan of the appliance. In addition, electronic control of BLDC motors allows better speed regulation and improved performance under varying load conditions. The study also discusses recent advancements in control techniques, including sensor less operation and inverter-based drives. A comparison with traditional mixer grinders highlights that BLDC-based systems can significantly improve efficiency while providing quieter and more reliable operation. The paper concludes by identifying current challenges such as higher cost and control complexity, along with future opportunities for smart and energy-efficient kitchen appliances.*

Keywords: BLDC Motor, Mixer Grinder, Energy Efficiency, Low Noise Operation, Brushless DC Motor, Electronic Commutation, Motor Control, Power Electronics, Household Appliances, Inverter Drive, Sustainable Technology.

I. INTRODUCTION

Mixer grinders have become an essential part of modern households, making food preparation faster and more convenient. They are commonly used for grinding spices, preparing pastes, and mixing ingredients. Most of the mixer grinders available in the market today are powered by universal motors because of their simple design and ability to operate at high speeds. However, these motors come with several drawbacks such as high noise levels, lower efficiency, and frequent maintenance due to brush wear and sparking.

In recent years, there has been a growing demand for energy-efficient and low-noise household appliances. This has led to the exploration of alternative motor technologies, among which Brushless DC (BLDC) motors have gained significant attention. Unlike universal motors, BLDC motors do not use brushes for commutation. Instead, they rely on electronic control, which reduces mechanical losses and improves overall performance. As a result, BLDC motors operate more quietly, consume less power, and have a longer lifespan.

The advancement in power electronics and control systems has made it possible to use BLDC motors in applications like mixer grinders. With the help of inverters and electronic speed controllers, precise control over speed and torque can be achieved, leading to better efficiency and consistent performance even under varying load conditions.

This paper focuses on reviewing the use of BLDC motors in mixer grinders, particularly in terms of reducing noise and improving efficiency. It also highlights the working principles, advantages, limitations, and future possibilities of this technology.

Conventional mixer grinders commonly use universal motors, which, although capable of providing high speed, suffer from several major drawbacks. These motors produce excessive noise during operation due to brush friction and

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sparking, making them uncomfortable for daily household use. In addition, they have lower energy efficiency because of higher mechanical and electrical losses, leading to increased power consumption.

Another important issue is maintenance. The presence of brushes in universal motors results in wear and tear over time, reducing the lifespan of the appliance and increasing maintenance costs. Furthermore, speed control in such motors is not very precise, which can affect the consistency of grinding performance.

With the increasing demand for energy-efficient and user-friendly appliances, there is a need to develop a mixer grinder system that operates with lower noise, higher efficiency, better durability, and improved control. This creates the need to explore alternative motor technologies such as BLDC motors for modern kitchen applications.

Table No. 1: Comparison analysis of Motor

Para	Universal Motor	BLDC Motor	Induction Motor
Speed	Very High (10,000–20,000 RPM)	High (3,000–15,000 RPM)	Moderate (1,500–3,000 RPM)
Noise Level	Very High	Low	Very Low
Efficiency	Low (~50%)	High (~80–90%)	Moderate (~70–85%)
Maintenance	High	Low	Very Low
Sound Source	Brush friction, sparking	Switching electronics	Magnetic hum only

(a) Universal motor (b) BLDC motor (c) Induction motor

Fig.1.1: Motor (a), (b), (c)

II. LITERATURE SURVEY

Several researchers have studied the performance and efficiency improvement of mixer grinders by replacing conventional universal motors with Brushless DC (BLDC) motors. A study by Nayak and Shivarudraswamy (2022) [1] presented a detailed comparison between BLDC and universal motors used in mixer grinders. Their analysis showed that BLDC motors provide significantly higher efficiency, nearly up to 80%, compared to around 50% efficiency in conventional motors. The improvement was mainly due to reduced mechanical losses and the absence of brushes, which also contributes to lower noise levels.

Further research by the same authors in 2020 [2] explored the use of solar-powered BLDC motor drives for mixer grinders using different converter topologies such as boost, buck, and buck–boost converters. These studies demonstrated that integrating renewable energy sources with BLDC motors not only improves energy efficiency but also promotes sustainable operation. However, the addition of power converters increases system complexity and cost.

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In the area of motor control, Gamazo-Real et al. (2010) [3] and Geraee et al. (2011) [4] focused on sensorless control techniques for BLDC motors. Their work highlighted that sensorless methods eliminate the need for physical sensors, reducing cost and improving reliability. However, these techniques may face challenges in accuracy, especially at low speeds. Similarly, Porselvi et al. (2014) [5] introduced an artificial neural network (ANN)-based control approach, which improves speed control and adaptability but requires higher computational resources.

Das et al. (2020) [6] proposed an optimized control scheme for BLDC motors, achieving improved efficiency and better dynamic performance. Advanced control methods such as Field Oriented Control (FOC), discussed by Zhang and Chen (2017), [7] offer precise control over torque and speed, making them suitable for high-performance applications. However, such techniques are complex and may not be easily implemented in low-cost household appliances.

Fundamental studies by Pillay and Krishnan (1989) [8] provided important insights into the modeling and simulation of BLDC motors, which serve as a base for further research. Other contributions by researchers like Bose (2002) [9] and Krishnan (2001) [10] [19] focused on power electronics and motor drive systems, enabling the development of efficient and reliable BLDC motor control strategies.

In addition, Singh and Singh (2009) [11] worked on improving power quality in BLDC motor drives, which helps in reducing harmonics and improving overall system performance. Recent studies by Kumar and Singh (2019)[12] [17] and Sharma and Dubey (2019) [14] [18]emphasized the importance of energy-efficient BLDC motor applications in household appliances, highlighting their potential in reducing power consumption.

Moreover, the integration of modern technologies such as IoT has been explored by Li and Wang (2020), [15] where smart control of BLDC motor-based appliances allows remote monitoring and improved user interaction. Despite these advancements, challenges such as cost, system complexity, and lack of widespread adoption still remain. [16]

Ref.

Ref. No.	Author & Year	Method / Focus	Key Findings	Limitations
[1]	Nayak & Shivarudraswamy (1)	Efficiency comparison (BLDC vs Universal Motor)	BLDC shows ~80% efficiency vs ~50% in universal motor	Higher cost not addressed
[2]	Nayak et al. (2)	Solar-fed BLDC with boost converter	Improved efficiency and energy utilization	System complexity increases
[3]	Nayak et al. (3)	Buck-boost converter for BLDC mixer	Stable operation under varying input	Cost and size issues
[4]	Nayak et al. (4)	Buck converter-based BLDC system	Efficient power conversion	Limited real-time testing
[5]	Gamazo-Real et al. (5)	Sensorless BLDC control	Eliminates sensors, reduces cost	Accuracy issues at low speed
[6]	Geraee et al. (6)	Adaptive speed control	Improved dynamic response	Complex control algorithm
[7]	Porselvi et al. (7)	ANN-based control	Intelligent speed control	High computational requirement
[8]	Das et al. (8)	Optimized control scheme	High efficiency and performance	Implementation cost
[9]	Pillay & Krishnan (9)	Modeling of BLDC motor	Accurate simulation models	Not application-specific
[10]	Hendershot &	Motor design	Improved motor	Theoretical focus

	Miller (10)	techniques	efficiency	
[11]	Krishnan (11)	Motor drive control	Comprehensive analysis	Lacks appliance application
[12]	Bose (12)	Power electronics for drives	Advanced drive systems	Complex for small appliances
[13]	Singh & Singh (13)	Power quality improvement	Reduced harmonics	Extra circuitry needed
[14]	Mohan et al. (14)	Power electronics fundamentals	Efficient converters	Not specific to BLDC mixer
[15]	Rashid (15)	Power electronics handbook	Wide application support	General study
[16]	Kumar & Singh (16)	Solar BLDC system	Renewable energy integration	Cost and availability
[17]	Sharma & Dubey (17)	Energy-efficient appliances	Reduced power consumption	Limited experimental data
[18]	Jain & Agarwal (18)	High-efficiency BLDC drive	Improved system performance	Expensive setup
[19]	Zhang & Chen (19)	Field Oriented Control	Precise torque and speed control	Complex implementation
[20]	Li & Wang (20s)	IoT-based BLDC control	Smart monitoring and control	Security and cost issues

Table No.1: Comparison table

III. RESEARCH ANALYSIS

1. High Initial Cost: Most studies show that BLDC motors provide high efficiency and better performance, but very few researchers focus on reducing system cost. This makes BLDC-based mixer grinders expensive and limits their use in low-cost household applications [1], [2], [18].
2. Complexity of Control Systems: Advanced control techniques such as sensorless control, Field Oriented Control (FOC), and AI-based methods improve performance, but they increase system complexity. There is a need for simpler, cost-effective control strategies [5], [6], [7], [19].
3. Limited Focus on Noise Optimization: Although BLDC motors are quieter than conventional motors, very limited research has been carried out specifically on noise reduction at high-speed operation in mixer grinders [1], [17].
4. Lack of Compact and Practical Design: Most research focuses on efficiency and performance, but compact, lightweight, and user-friendly designs suitable for household appliances are not widely explored [10], [11].
5. Insufficient Real-Time Implementation: Many studies are based on simulation results rather than real-time implementation. Practical testing under actual working conditions is still limited [8], [9].
6. Limited Integration with Smart Technologies: Only a few studies explore integration with IoT and smart monitoring systems. Smart BLDC-based appliances are still in early development stages [20].
7. Challenges in Renewable Energy Integration: Solar-powered BLDC systems show promising results, but issues like cost, reliability, and availability of components are not fully addressed [2], [3], [16].

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IV. LIMITATIONS

Although BLDC motor-based mixer grinders offer many advantages, they also have certain limitations that need to be considered. One of the main drawbacks is the higher initial cost. BLDC motors and their electronic controllers are more expensive than traditional universal motors, which makes the overall appliance costlier for consumers.

Another limitation is the complexity of the control system. Unlike conventional motors that can operate directly on AC supply, BLDC motors require an electronic controller, inverter, and sometimes sensors for proper operation. This increases the design complexity and makes the system more difficult to develop and troubleshoot.

The maintenance and repair process can also be challenging. While BLDC motors themselves require less maintenance due to the absence of brushes, any fault in the electronic controller or driver circuit may require skilled technicians, which can increase servicing costs.

Additionally, BLDC systems can be sensitive to voltage fluctuations and power quality issues. Improper voltage supply may affect performance or even damage the controller circuit.

Another concern is the availability of components and technology in low-cost markets. Since BLDC-based mixer grinders are relatively new, they are not as widely available as conventional models. Lastly, although BLDC motors produce less noise, noise at very high speeds and vibrations can still be an issue and requires further optimization.

V. WORKING PRINCIPLE OF BLDC MOTOR BASED MIXTURE GRINDER

The working principle of a BLDC motor-based mixer grinder is based on electronic commutation and electromagnetic interaction. Unlike conventional mixer grinders that use universal motors with brushes, BLDC motors operate without brushes, making the system more efficient and reliable.

In this system, the main components include a BLDC motor, an electronic controller (inverter or driver circuit), a power supply, and the grinding mechanism (blades and jar). When the mixer grinder is switched on, the AC supply is first converted into DC using a rectifier. This DC power is then supplied to the electronic controller. The controller plays a crucial role by converting the DC supply into a sequence of controlled electrical signals, which are applied to the stator windings of the BLDC motor. These signals generate a rotating magnetic field inside the motor. The rotor, which contains permanent magnets, follows this rotating magnetic field and starts rotating.

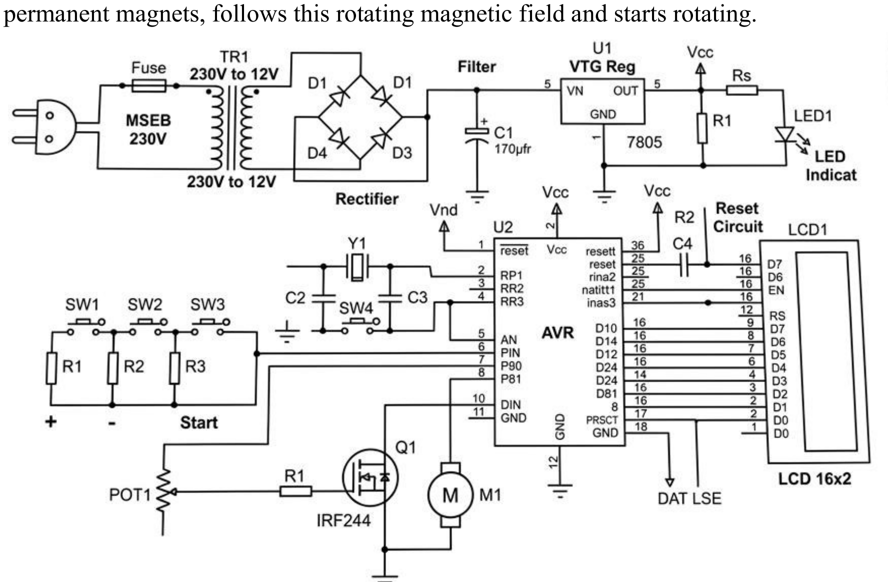

Fig.1.2: Circuit diagram

As the rotor rotates, the shaft connected to it also rotates, which in turn drives the blades of the mixer grinder. The rotation of the blades performs the grinding and mixing operation. The speed of the motor can be precisely controlled by adjusting the input voltage or through pulse-width modulation (PWM) techniques in the controller. In advanced systems, sensorless control methods are used, where the position of the rotor is detected using back electromotive force (back-EMF), eliminating the need for physical sensors. This further improves the reliability and reduces the cost of the system.

VI. CONCLUSION

BLDC motor-based mixer grinders offer a modern and efficient alternative to traditional mixer grinders that use universal motors. They provide significant improvements in terms of energy efficiency, noise reduction, and durability. The absence of brushes not only reduces maintenance but also enhances the overall performance of the system. With the help of advanced electronic control techniques, BLDC motors ensure better speed regulation and consistent output under different operating conditions.

Although there are some challenges such as higher initial cost and system complexity, ongoing advancements in power electronics and control technologies are expected to overcome these limitations. In the future, BLDC-based mixer grinders have great potential to become widely adopted due to their energy-saving capability, low noise operation, and suitability for smart and sustainable household applications.

Advantages

- High efficiency (less power consumption)
- Low noise operation (no brush friction)
- Longer lifespan due to absence of brushes
- Low maintenance requirements
- Better speed control and precision
- Smooth and stable operation
- Less heat generation
- Reduced mechanical losses
- Compact and reliable design
- Environment-friendly and energy saving
- Suitable for smart and modern appliances

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