



Thermal Safety and Efficiency of a 24 Volt DC Motor Used as a Prime Mover for a Single-Phase Generator

Sri Agustina, M. Aldi Ramadhan, Herlina*, Wirawan Adipradana

Department of Electrical Engineering, Universitas Sriwijaya, South Sumatera, Indonesia

*Correspondence email: herlinawahab@unsri.ac.id

Received: 05/12/2025

Revised: 28/12/2025

Accepted: 05/01/2026

Abstract: Brushed DC motors are often used as low-cost prime movers in small generator sets. However, users rarely evaluate thermal safety together with efficiency when the set operates under repeated electrical loads. This study investigates a 24 V, 750 W brushed DC motor mechanically coupled to a 220 V, 50 Hz single-phase synchronous generator and a lamp-based resistive load bank. Three generator load levels were tested (1000 W, 1400 W, and 2600 W). Each test ran for 10 minutes to represent a short-time duty that is practical for repeated laboratory trials and long enough to reveal a clear temperature trend while maintaining safe operation. The DC terminal voltage (V), input current (A), and motor surface temperature (°C) were recorded every 2 minutes. Input power, temperature rise, estimated loss power, output power, and apparent efficiency were then computed at the 10-minute mark. The results show a monotonic temperature rise with load: after 10 minutes, the motor surface temperature reached about 36.0°C (1000 W), 39.3°C (1400 W), and 41.5°C (2600 W), corresponding to a 9–15 K rise above ambient. The apparent efficiency remained high at 94.3–96.3%. These findings support a simple and replicable approach to discussing the thermal safety and efficiency of small motor-generator sets in laboratory practice.

Keywords: DC-motor; thermal; efficiency; single-phase; generator



SDGs Problem Solving

The study aligns with SDGs Chapter #7, examining the thermal safety and efficiency of a DC motor-generator combination with IEC 60034-1 standards. It aims to enhance sustainability, safety, and efficiency in small-scale electricity generation systems by improving energy reliability, reducing power losses, and extending the life of equipment.

Conflict of Interest Statement: The author(s) declares that the research was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

Copyright: © ASIIMETRIK. This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Jurnal Asimetrik: Jurnal Ilmiah Rekayasa dan Inovasi - ASIIMETRIK is an open access and peer-reviewed journal published by Faculty of Engineering, Universitas Pancasila, Indonesia.



1. INTRODUCTION

Reliable and good-quality electrical power is essential for households, campuses, training centers and small industries, especially where grid disturbances are still common. In these contexts, small generator sets are widely used as backup or stand-alone sources to keep essential loads operating. In many educational and vocational laboratories, the prime mover of such small gensets is not a diesel engine but a low voltage brushed DC motor supplied by a battery bank. This arrangement is attractive because speed is simple to control, the system is clean and quiet, and the same test bench can be reused for teaching electromechanical energy conversion. However, when a brushed DC motor is used as a genset driver, its thermal behavior becomes a key constraint on safe and reliable operation, particularly when the generator is heavily loaded and the set is run repeatedly in practical sessions.

From a machine-design perspective, almost all electromagnetic losses in electric machines eventually appear as heat. If this heat is not removed effectively, the winding temperature rises, the insulation ages faster, and the probability of failure increases. Reviews on loss mechanisms and cooling in electric machines underline that thermal management is now one of the main bottlenecks in improving efficiency and power density (Gundabattini et al., 2021). A survey of advanced cooling techniques further emphasizes that controlling temperature rise is essential to maintaining torque capability and extending lifespan, regardless of machine topology (Q. Wang et al., 2022). International standards, such as IEC 60034-1, formalize these issues through permissible temperature-rise limits for each insulation class and ambient condition; continuous operation above these limits can significantly shorten winding life (IEC, 2017).

Abdullah et al., experimentally measured the temperature rise of a small, brushed DC motor under various load conditions and showed that local hot spots arise near the brushes and commutator before heat propagates to the housing (Abdullah, Wahab and Rasid, 2019). Follow-up work from the same group examined the temperature profiles of different motor components under varying voltages and speeds, confirming that modest changes in operating points can markedly alter the internal temperature field (Wahab, Abdullah and Rasid, 2018; Abdullah, Wahab and Rasid, 2019). Beyond these experiments, Li et al., combined tests and numerical modelling to investigate the vacuum thermal characteristics of a brushed DC motor, while Cui et al., proposed an online diagnosis method for interturn short-circuit faults based on a first-principal model and hidden Markov modelling (Cui, Fan and Li, 2018; Li et al., 2023). Together, these studies indicate that temperature is a sensitive indicator of both electrical loading and mechanical or insulation faults in brushed DC machines.

Despite this growing literature, many studies still discuss temperature behaviour or efficiency as separate topics, even though both originate from the same loss mechanisms in the machine. This separation makes it difficult for practitioners to judge whether a small motor-generator set operates safely while delivering useful power in short laboratory sessions. At the same time, temperature-rise limits remain a central safety reference because excessive temperature accelerates insulation ageing and reduces winding lifetime (IEC, 2017). A new discourse on thermal behavior and loss mechanisms underscores that operational variables and loading patterns can influence the heating rate and the permissible margin to thermal thresholds (Gundabattini et al., 2021; Zhoghuo and Alex, 2024).

The specific research gap is the absence of empirical data and a clear analysis workflow that concurrently presents (1) temperature increase as a thermal-safety metric and (2) apparent efficiency as a performance metric for a low-voltage brushed DC motor operating a single-phase generator under regulated load increments. Advanced thermal modeling and monitoring approaches are still changing ([Kiran et al., 2025](#); [Meier and Strangas, 2025](#); [Srivastava et al., 2025](#); [Łach and Svyetlichnyy, 2025](#)), but lab users still require a simple way to do it that can be done with basic tools and done over and over again.

In response, this work focuses on a 24 V, 750 W brushed DC motor acting as the prime mover for a 220 V, 50 Hz single-phase synchronous generator in a laboratory-scale genset. The research evaluates three generator load levels (1000 W, 1400 W, and 2600 W), representing light, medium, and heavy loading. For each load, the genset is run for 10 minutes while the DC input voltage and current and the motor surface temperature are recorded at regular intervals. The work quantifies the motor surface temperature trend and compares the resulting temperature rise against typical insulation-class limits defined in IEC 60034-1 ([IEC, 2017](#)). In parallel, it estimates loss power and apparent efficiency at the end of a fixed short-time operation window to enable fair comparison across load cases.

The objectives of this study are (i) to experimentally quantify how generator loading and operating time affect the surface temperature and copper losses of a low-voltage brushed DC motor used as a genset driver; (ii) to determine whether the resulting temperature rise indicates the occurrence of panas lebih under the tested conditions; and (iii) to provide a simple, measurement-based characterization that can be used by laboratory instructors and small-system operators to define safe operating regions. Correspondingly, the contributions of this paper are threefold. First, it provides a systematic experimental dataset of electrical and thermal behavior for a realistic motor–generator configuration frequently encountered in educational settings. Second, it clarifies the relationship between load level, input power, estimated copper losses and surface temperature rise for a 24V, 750 W brushed DC motor, explicitly linking these results to insulation-class limits from IEC 60034-1. Third, it proposes a straightforward experimental and computational procedure—using only standard instruments such as multimeters and thermometers—that can be replicated in other laboratories to evaluate overheating risk and support teaching on efficiency, losses and thermal limits in electric machines.

2. METHODOLOGY

This study was carried out on a laboratory-scale motor–generator set in which a low-voltage brushed DC motor is used as the prime mover of a single-phase synchronous generator. The objective of the methodology is to obtain, in a controlled and repeatable way, the electrical and thermal data required to evaluate how different generator loads affect the motor's surface temperature, losses and efficiency. The research following this flowchart as shown on [Figure 1](#).

2.1. Experimental Setup

The test bench consists of a 24 V brushed DC motor (see [Figure 2a](#)) supplied from a 24 V battery bank (two 12 V automotive batteries in series) and mechanically coupled to a 220 V, 50 Hz single-phase synchronous generator (see [Figure 2b](#)).

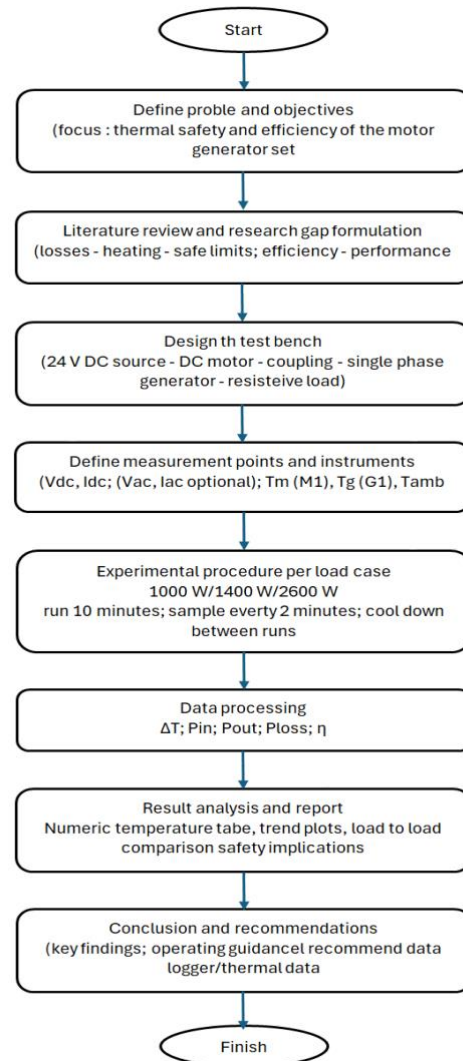


Figure 1. Flowchart of the research



(a). DC motor



(b). Synchronous AC Generator 1 phase

Figure 2. The motor and generator used in the study

The generator output powers a lamp-based load bank that can be configured to three nominal load levels: light (about 1000 W), medium (about 1400 W), and heavy (approximately 2600 W). A digital voltmeter connected to the motor terminals measures the input voltage, and a clamp-type DC ammeter on the supply conductor measures the input current. Two contact temperature sensors were utilized to make sure that the surface temperature measurements were always the same.

We measured the motor surface temperature, T_m (°C), at a set position on the motor mid-housing (M1). At a set position on the generator mid-housing (G1), the generator surface temperature, T_g (°C), was monitored. We measured the ambient temperature, T_{amb} (°C), near the set (about 0.5 m) to use as a baseline for the temperature rise. This fixed-point method makes it easier to repeat tests with different loads. To have better temporal resolution and less ambiguity when reading, future work can switch out the handheld thermometers for type-K thermocouples that are coupled to a multi-channel temperature data recorder. Table 1 describes the specification of the DC motor and the generator used in this research.

Table 1. Main specifications of the DC motor and generator

Component	Parameter	Value
DC motor	Rated voltage	24 V DC
	Rated current	28 A
	Rated speed	2600 rpm
	Rated output power	750 W
Synchronous gen (single phase)	Rated voltage	220 V AC
	Rated current	13 A
	Frequency	50 Hz
	Rated speed	1500 rpm
	Power factor	1.0

2.2. Test Procedure

Before each test, the motor-generator set is left idle until the motor housing temperature is close to ambient. The ambient and initial motor temperatures are recorded as a reference for temperature rise (see Figure 3).

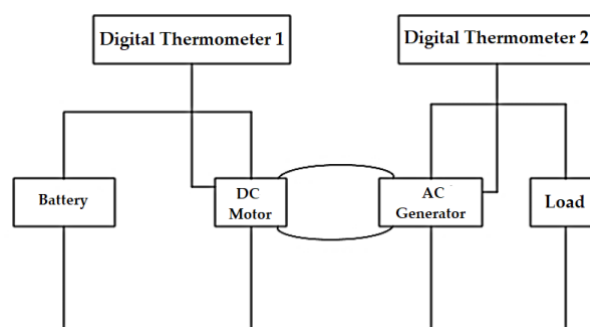


Figure 3. Block diagram of the experimental test bench

Figure 3 shows a block diagram of the setup for an experimental test bench that will be used to test how well and electromechanical energy conversion system works. This system has a DC motor and an AC generator that are linked together in a way that makes them work together. The process begins with a battery, which is the main source of power. The battery sends electricity to the DC motor, which makes it turn. The coupling link then sends the mechanical rotation straight to the AC generator. The AC generator changes the DC motor's rotational input into electrical energy, which is called alternating current (AC). After that, the AC output is sent to a connected load, which is like a real-life situation where devices or systems use electrical energy.

The setup includes two digital thermometers that keep an eye on and measure the system's thermal properties while it is running. Digital Thermometer 1 is connected to the DC motor, which lets you check the motor's temperature in real time. Digital Thermometer 2 is also connected to the AC generator and load, which lets you see how the temperature changes in these parts.

Before each test, the motor-generator set was left idle until the motor surface temperature approached the ambient temperature. The selected generator load (1000 W, 1400 W, or 2600 W) was then connected. The set was operated for 10 minutes to represent a short-time duty that is practical for repeated laboratory trials and long enough to reveal a clear heating trend without pushing the machine toward unsafe conditions. During operation, the following quantities were recorded at 0, 2, 4, 6, 8, and 10 minutes: DC terminal voltage at the motor, V (V); DC input current, I (A); motor surface temperature, T_m (°C); and generator surface temperature, T_g (°C). After each run, the supply and load were switched off, and the set was allowed to cool down to comparable initial conditions before the next load case.

2.3. Data Processing

The electrical input to the motor at each measurement instant is obtained from the standard DC power expression (Chapman, 2012):

$$P_{in} = V \cdot I \quad (1)$$

where P_{in} is DC power (Watt); V is the DC terminal voltage (Volt); and I is the input current (Ampere). The temperature rise of the motor housing is defined as the difference between the motor temperature (T_m) and the ambient temperature (T_{amb}) (IEC, 2017).

$$\Delta T = T_m - T_{amb} \quad (2)$$

where T_m is the measured motor surface temperature (°C) and T_{amb} is the ambient temperature (°C) recorded at the beginning of the test.

For each load level, the average loss power over the 10-minute interval is estimated from the motor's thermal capacitance and the observed temperature rise, assuming that the dominant contribution is Joule (I^2R) heating in the windings, following common practice in lumped-parameter thermal models of small machines (Boglietti et al., 2009).

The mechanical output power of the motor is then approximated as (Chapman, 2012):

$$P_{out} = P_{in} - P_{loss} \quad (3)$$

In this work, P_{in} , P_{loss} , and P_{out} are expressed in watts (W). The temperature rise is defined as $\Delta T = T_m - T_{amb}$, reported in kelvin (K), which is numerically identical to °C difference. The corresponding efficiency can be calculated using the formula (Chapman, 2012):

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% \quad (4)$$

These calculations are performed at the 10-minute mark for each load level to obtain comparable steady-state indicators of loss and efficiency.

3. RESULTS AND DISCUSSION

3.1. Motor temperature rise under different generator loads

The evolution of motor surface temperature for the three generator load levels is shown in Figure 4. Figure 4 demonstrates that, after the initial minutes of operation, the temperature curves exhibit distinct characteristics: the 1000 W curve displays a reasonably gentle slope, the 1400 W curve is intermediate, and the 2600 W curve reveals the most pronounced increase. All three curves start from approximately the same ambient condition (around 27°C) and then rise gradually during the 10-minute interval. After 10 minutes, the motor surface temperature reaches roughly 36°C at 1000 W, about 39.3°C at 1400 W, and around 41.6°C at 2600 W. Thus, both the final temperature and the slope of the curve increase with generator load: the 1000 W curve is the flattest, the 1400 W curve lies in between, and the 2600 W curve is clearly the steepest. All data can be seen in Table 2.

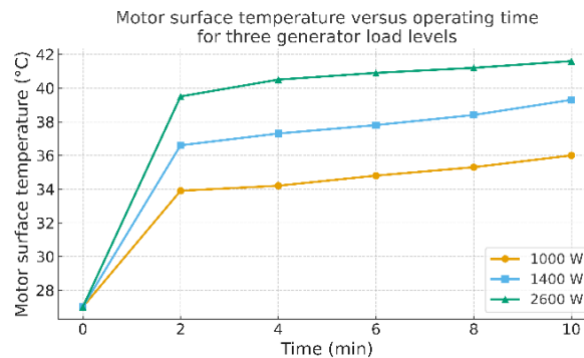


Figure 4. Motor surface temperature versus operating time

Table 2. Motor surface temperature T_m at point M1 during 10-minute operation (recorded every 2 minutes)

Time (min)	T_m at 1000 W (°C)	T_m at 1400 W (°C)	T_m at 2600 W (°C)
0	27.0	27.0	27.0
2	33.8	36.5	39.3
4	34.2	37.3	40.5
6	34.8	37.8	40.9
8	35.3	38.4	41.2
10	36.0	39.0	41.5

This behaviour reflects classical Joule heating in the windings, where copper losses proportional to I^2R accumulate and then diffuse to the housing (Condit, 2010; Hong, 2025). Similar monotonic temperature rises and steeper gradients at higher torque were reported by Abdullah et al. for small, brushed DC motors under varying mechanical load and supply conditions (Abdullah, Wahab and Rasid, 2019). In the present tests, the temperature profiles are smooth and do not show abrupt changes, which are consistent with a healthy machine and differ from the faster and more irregular heating trends typically associated with bearing damage or other mechanical faults.

When the measured temperature rise is compared with typical limits for low-voltage machines in IEC 60034-1, the 9–15 K increase observed over 10 minutes remains far below the allowable values for common insulation classes. Together with recent reviews on thermal management that highlight

critical issues mainly under long duty cycles, high power density, or restricted cooling (Condit, 2010; Q. Wang et al., 2022; X. Wang et al., 2022), this indicates that, for the short laboratory duty cycle considered here, all three load levels are thermally safe, although the 2600 W case provides the smallest thermal margin and would be the first to approach critical limits if the operating time or ambient temperature were increased.

3.2. Estimated Loss of Power and Apparent Efficiency

At the end of the 10-minute interval, the electrical input power of the DC motor is calculated from the DC power expression $P_{in}=VI$. Using a lumped thermal-capacitance approach, the measured temperature rise ΔT is converted into an average loss power P_{loss} over 600 s. The effective output power is then approximated by $P_{out}=P_{in}-P_{loss}$, and the apparent efficiency of the motor–generator set is obtained from equation (4). The resulting values are summarised in Table 3. The variation of apparent efficiency with generator load is illustrated in Figure 5.

Table 3. Input power, estimated loss power, output power and apparent efficiency (10-minute interval)

Load (W)	Pin (W)	Ploss (W)	Pout (W)	η (%)
1000	791.12	28.49	762.64	96.3
1400	793.80	38.93	754.87	95.0
2600	814.58	46.21	768.37	94.3

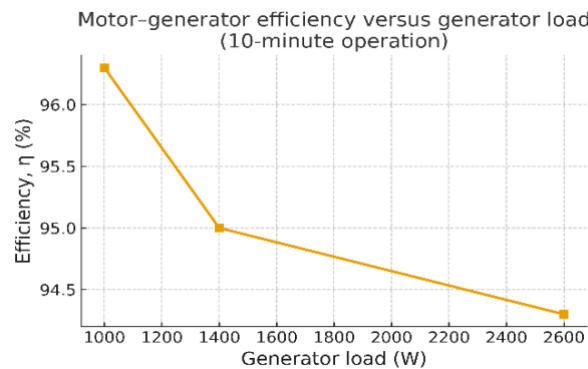


Figure 5. Motor–generator efficiency versus generator load after 10 minutes of operation

Table 3 shows that the estimated loss of power increases from about 28.5 W at 1000 W to roughly 46.2 W at 2600 W. This rise with load is consistent with the dominant role of copper losses, since higher generator load requires higher motor current and therefore larger I^2R losses in the windings (Condit, 2010; Chapman, 2012). At the same time, the apparent efficiency of the motor–generator set remains high, in the range of about 94–96%, and decreases only slightly as load increases. The profile in Figure 3 is in line with the typical efficiency characteristic of DC motors: efficiency peaks near an optimum operating point and then falls gradually when total losses grow more rapidly than useful output power (Abdullah, Wahab and Rasid, 2019; X. Wang et al., 2022).

Compared with experimental and review studies on efficiency in electric machines, the values above 94% obtained here are reasonable for a small DC motor driving a single-phase generator, particularly because they are derived from a simplified thermal model instead of a full dynamometer test according to IEC procedures (Condit, 2010; IEC, 2017; X. Wang et al., 2022).

The numbers in [Table 2](#) are therefore best interpreted as physically consistent indicators of trend rather than definitive efficiency ratings, but the direction and magnitude of the changes in loss power and efficiency with load closely match theory and previous experimental observations.

3.3. Comparative Discussion and Practical Implications

Overall, [Table 3](#), [Figure 4](#) and [Figure 5](#) provide a coherent description of the load-dependent behavior of the 24V, 750 W DC motor driving the single-phase generator. The measured temperature and loss patterns match those reported for healthy brushed DC motors operating under varying load and speed and do not display the abnormal signatures associated with mechanical or electrical faults ([Condit, 2010](#); [Abdullah, Wahab and Rasid, 2019](#)). From a practical standpoint, the results suggest that this motor–generator configuration can be used safely for short-duration teaching experiments at all three tested load levels, provided that reasonable cooling intervals are applied—especially at 2600 W. The experimental procedure, which combines straightforward voltage–current–temperature measurements with a lumped thermal model, offers a simple way for laboratories to relate generator load, losses, efficiency and temperature rise to the thermal limits defined by standards such as IEC 60034-1 ([Aziz, Atkinson and Salimin, 2017](#); [IEC, 2017](#); [Gundabattini et al., 2021](#); [Q. Wang et al., 2022](#)). Therefore, it serves both as a tool for assessing overheating risk in small DC motor-driven sets and as a pedagogical framework for illustrating the interplay between loading, losses, and thermal constraints in electrical machines.

4. CONCLUSION

This study sets out to clarify how generator load affects the thermal and performance behavior of a 24 V, 750 W brushed DC motor used as the prime mover of a single-phase generator, to assess whether such operation leads to harmful overheating, and to test whether a simple laboratory-based procedure is sufficient to evaluate these issues.

The measurements reveal a coherent load-dependent response. As the generator load is raised from about 1000 W to 2600 W, the motor experiences a larger temperature rise, greater power loss, and a small reduction in apparent efficiency. After 10 minutes of operation, the housing temperature increase remains in the range of roughly 9–15 K above ambient, the estimated losses lie between about 28 W and 46 W, and the efficiency of the motor–generator set stays close to 94–96%. These values suggest that, for the short duty cycle considered, the motor still operates within a safe thermal margin, although the highest load level clearly represents the most demanding condition and would be the first to approach critical limits if the operating time or ambient temperature were increased.

Methodologically, the work shows that combining basic measurements of voltage, current and surface temperature with a lumped thermal-capacitance model is sufficient to obtain a meaningful picture of the relationship between load, losses, efficiency and temperature in a small genset. The required instruments and calculations are simple, making the procedure suitable for both practical evaluation and teaching purposes in typical electrical machines laboratories. The main contribution and novelty lie in treating a low voltage brushed DC motor explicitly as the driving element of a single-phase generator in a configuration that reflects instructional and small backup systems and in quantifying how discrete load steps and short operating intervals shape its thermal and performance margins. In this sense, the study achieves its objectives and provides a practical reference for defining

safe operating envelopes and designing future laboratory and research work on similar motor–generator sets.

REFERENCES

- Abdullah, N.F., Wahab, A.A. and Rasid, M.A.H. (2019) 'Study of temperature rise in small, brushed DC motor components under different speed', *IOP Conference Series: Materials Science and Engineering*, 469(1), p. 012098. Available at: <https://doi.org/10.1088/1757-899X/469/1/012098>.
- Aziz, R., Atkinson, G.J. and Salimin, S. (2017) 'Thermal Modelling for Permanent Magnet Synchronous Machine (PMSM)', *International Journal of Power Electronics and Drive Systems (IJPEDS)*, 8(4), pp. 1903–1912. Available at: <https://doi.org/10.11591/ijpeds.v8.i4.pp1903-1912>.
- Boglietti, A. et al. (2009) 'Evolution and Modern Approaches for Thermal Analysis of Electrical Machines', *IEEE Transactions on Industrial Electronics*, 56(3), pp. 871–882. Available at: <https://doi.org/10.1109/TIE.2008.2011622>.
- Chapman, S.J. (2012) *Electric Machinery Fundamentals*. McGraw-Hill. [Print].
- Condit, R. (2010) 'Brushed DC Motor Fundamentals - AN905'. Microchip Technology Inc. Available at: <https://ww1.microchip.com/downloads/en/appnotes/00905b.pdf>. (Accessed: 1 June 2025).
- Cui, R., Fan, Y. and Li, C. (2018) 'On-Line Inter-Turn Short-Circuit Fault Diagnosis and Torque Ripple Minimization Control Strategy Based on OW Five-Phase BFTHE-IPM', *IEEE Transactions on Energy Conversion*, 33(4), pp. 2200–2209. Available at: <https://doi.org/10.1109/TEC.2018.2851615>.
- Gundabattini, E. et al. (2021) 'A review on methods of finding losses and cooling methods to increase efficiency of electric machines', *Ain Shams Engineering Journal*, 12(1), pp. 497–505. Available at: <https://doi.org/10.1016/j.asej.2020.08.014>.
- Hong, Y. (2025) 'Evolution and Analysis of Brush Structures in Brushed Motors', *Highlights in Science, Engineering and Technology*, 149, pp. 116–121. Available at: <https://doi.org/10.54097/awpvcq97>.
- IEC (2017) *Rotating electrical machines - Part 1: Rating and performance*. Geneva, Switzerland: Multiple. Distributed through American National Standards Institute (ANSI). [Print].
- Kiran, A. et al. (2025) 'Explainable AI in thermal modelling enhancing precision in thermal gradient monitoring for additive manufacturing using LSTM networks', *Thermal Science and Engineering Progress*, 60, p. 103465. Available at: <https://doi.org/10.1016/j.tsep.2025.103465>.
- Łach, Ł. and Syetlichnyy, D. (2025) 'Advances in Numerical Modeling for Heat Transfer and Thermal Management: A Review of Computational Approaches and Environmental Impacts', *Energies*, 18(5), p. 1302. Available at: <https://doi.org/10.3390/en18051302>.
- Li, T. et al. (2023) 'Experimental study and numerical analysis of vacuum thermal characteristics of brush DC motor', *Energy Storage and Saving*, 2(2), pp. 459–466. Available at: <https://doi.org/10.1016/j.enss.2023.01.001>.
- Meier, M. and Strangas, E.G. (2025) 'Cooling Systems for High-Speed Machines—Review and Design Considerations', *Energies*, 18(15), p. 3954. Available at: <https://doi.org/10.3390/en18153954>.
- Srivastava, M. et al. (2025) 'Fabrication and experimental investigation of a laboratory-scale organic Rankine cycle and data-driven optimization', *Energy*, 323, p. 135905. Available at: <https://doi.org/10.1016/j.energy.2025.135905>.
- Wahab, A.A., Abdullah, N.F. and Rasid, M. a. H. (2018) 'Mechanical Fault Detection on Electrical Machine: Thermal Analysis of Small Brushed DC Motor with Faulty Bearing', *MATEC Web of Conferences*, 225, p. 05012. Available at: <https://doi.org/10.1051/mateconf/201822505012>.
- Wang, Q. et al. (2022) 'Advances in Thermal Management Technologies of Electrical Machines', *Energies*, 15(9), p. 3249. Available at: <https://doi.org/10.3390/en15093249>.
-

- Wang, X. *et al.* (2022) '[A critical review on thermal management technologies for motors in electric cars](#)', *Applied Thermal Engineering*, 201, p. 117758. Available at: <https://doi.org/10.1016/j.applthermaleng.2021.117758>.
- Zhoghuo, Y. and Alex, K.H. (2024) '[Innovations in Thermal Management Techniques for Enhanced Performance and Reliability in Engineering Applications](#)', *Journal of Engineering Research and Reports*, 26(8), pp. 69–81. Available at: <https://doi.org/10.9734/jerr/2024/v26i81230>.

This page is blank on purpose