RESEARCH PROGRESS IN MECHANICAL AND MANUFACTURING ENGINEERING
e-ISSN: 2773-4765

RPMME

Vol. 7 No. 1 (2026) 180-187
https://publisher.uthm.edu.my/periodicals/index.php/rpmme

Field Study of Imported Lightweight Vehicles Disc Brake Operating Temperature at PLUS Highway Using Infrared Thermography

Jesssica Jatimin[1], Maznan Ismon[1*]

[1] *Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor MALAYSIA*

*Corresponding Author: maznan@uthm.edu.my
DOI: https://doi.org/10.30880/rpmme.2026.07.01.019

Article Info

Received: 1 December 2025
Accepted: 1 February 2026
Available online: 28 February 2026

Keywords

Disc Brake, Camera Infrared thermography, Operating Temperature, PLUS Highway

Abstract

This study investigates the temperature of disc brake systems in imported Honda vehicles during real highway driving in Malaysia using Infrared Thermography (IRT). The main aim is to observe how brake disc temperatures change under normal conditions along the PLUS Highway, particularly at the Yong Peng Utara toll area where frequent braking occurs. Temperature data were collected during morning, afternoon, and evening using a FLIR T640 thermal camera. Two emissive values, 0.95 and 0.35, were used to study their effect on temperature readings. The results showed that lower emissivity settings produced higher temperature values, highlighting the importance of correct calibration for accurate measurements. Environmental factors like air temperature, wind, and braking frequency also affected the brake temperatures, with the highest readings in the afternoon. Thermal images revealed hotspots that could cause uneven wear and reduced brake performance. This study confirms IRT as a safe and effective method for assessing brake temperatures in tropical conditions.

1. Introduction

Disc brakes are critical components in ensuring vehicle safety, functioning by converting kinetic energy into thermal energy through friction during deceleration. Under high-speed or frequent braking scenarios such as those encountered on Malaysia's PLUS Highway excessive heat buildup can reduce braking efficiency, accelerate component wear, and lead to safety-critical issues like brake fade [1][2]. This is especially relevant for imported models such as Honda vehicles, which are widely used across Malaysian roads. Despite the popularity of these vehicles, there remains a lack of research focused on real-world thermal behavior of their disc brakes under tropical highway conditions. This study aims to fill that gap by investigating the operating temperature of disc brakes in Honda vehicles during actual driving conditions using infrared thermography. The objectives are to evaluate heat distribution, identify thermal hotspots, and assess the influence of variables such as braking frequency, vehicle speed, ambient temperature, and road surface conditions. Previous models and simulations often rely on controlled environments or assume uniform behavior across substrates, neglecting the complexity of dynamic driving conditions and material-specific thermal responses [3][4]. This study aims to fill that gap by investigating the operating temperature of disc brakes in Honda vehicles during actual driving conditions using infrared thermography. The objectives are to evaluate heat distribution, identify thermal hotspots, and assess the influence of variables such as braking frequency, vehicle speed, ambient temperature, and road surface conditions. Previous models and simulations often rely on controlled environments or assume uniform behavior across substrates, neglecting the complexity of dynamic driving conditions and material-specific thermal responses [3][4]. Infrared thermography (IRT) has proven to be a reliable, non-invasive tool for assessing brake disc surface temperatures in real time [5][6]. This hotspots and researchers to monitor thermal gradients, detect hotspots, and study the transient thermal behavior of disc brakes under repeated use. Utilizing a FLIR T640 thermal imaging camera, this study records temperature data at various times of the day at the Yong Peng Utara toll area one of the frequent braking zones along the PLUS Highway. The captured data highlights the impact of tropical heat and frequent braking, confirming findings from past studies that link excessive heat accumulation to reduced braking efficiency and uneven disc wear [7][8]. Moreover, the effect of external parameters such as vehicle load, road gradient, and ambient humidity has been documented to significantly influence brake temperature [9][10]. Thermal expansion, brake fluid vaporization, and heat-induced vibrations such as brake become more pronounced under these conditions [11][12]. Repeated thermal cycling can also contribute to material fatigue, which is a common concern in extended downhill driving or during frequent acceleration-deceleration cycles at toll plazas [13]. Additional research has explored advanced methods for identifying thermal stress zones, including the use of statistical modeling and predictive diagnostics [14]. Silver-based infrared techniques, though effective, face cost and durability challenges, which this study addresses by focusing on efficient, real-time thermal monitoring of standard disc brake materials. Past findings suggest that uneven thermal distribution contributes to narrow wear paths and performance instability, especially in low-energy conditions or non-optimized materials [15]. By combining field data with thermographic imaging, this study presents an accessible and robust approach for evaluating brake safety in high-temperature tropical environments.

2. Methodology

This study was conducted through a field-based experimental approach aimed at evaluating the operating temperature of disc brakes in imported Honda vehicles under actual highway driving conditions. The primary method involved the use of Infrared Thermography (IRT), a non-contact technique for capturing surface temperature profiles in real-time. Data collection was carried out at Yong Peng Utara toll plaza, a location selected due to its frequent stop and go braking patterns, which replicate real-world thermal stress scenarios. A FLIR T640 thermal imaging camera (Figure 1) was employed to monitor and record the surface temperatures of front and rear disc brakes after the vehicle completed highway driving sessions. The camera, known for its high sensitivity and resolution, was positioned externally at a safe distance from the vehicle, allowing unobstructed capture of thermal radiation emitted by the brake components without disrupting brake operation. Thermal readings were taken at different times of day, morning, afternoon and evening to examine the influence of ambient temperature on heat distribution. A laser thermometer and a thermal anemometer were also used to supplement ambient temperature and wind flow readings, ensuring environmental conditions were properly accounted for in the analysis.

Fig. 1 *Infrared Thermography Camera (FLIR T640)*

This methodology offers a reliable and cost-effective approach to assessing brake thermal performance in field conditions, using passive thermography as a diagnostic tool. The findings obtained through this setup are expected to provide meaningful insight into the thermal management characteristics of disc brakes and support enhancements in design, safety, and material application for tropical environments.

To ensure consistency and reliability throughout the experimental process, a structured procedure was followed during the data collection phase. This procedure encompassed site preparation, equipment calibration, thermal imaging, environmental monitoring, and safety protocols. Each step was designed to minimize measurement error and ensure that data captured under real highway conditions were accurate and valid. The entire data collection workflow is outlined in Table 4.1, which summarizes the major activities and their respective details.

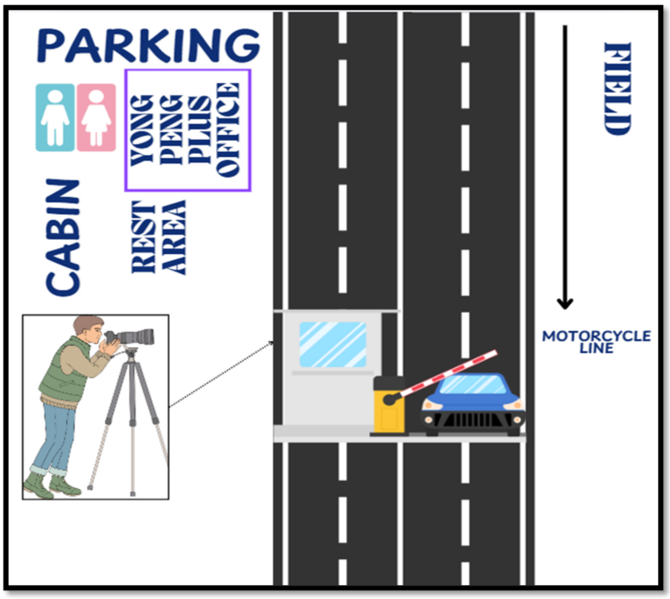

Fig 2 Yong Peng Toll Utara Johor

Figure 2 shows the thermal behaviour of the disc brake systems recorded at the PLUS Highway, specifically at the Yong peng (Johor) toll area. Data was collected during three different sessions morning, afternoon and evening, to observe the effect of environmental temperature on brake surface heat distribution. The primary focus is to investigate how thermal behaviour varies under real driving conditions throughout the day.

3. Results and Discussion

This study comprehensively analyzed the surface temperature behavior of disc brakes in imported Honda vehicles by employing infrared thermography (IRT) under actual highway driving conditions at the Yong Peng Utara toll plaza a location chosen for its frequent braking zones and dynamic traffic flow. The primary objective was to assess how different environmental conditions and infrared camera emissivity settings influence the thermal performance of disc brake systems during normal operation. Data were systematically collected across three distinct time intervals morning, afternoon, and evening to capture the effects of varying ambient temperatures, sunlight exposure, and traffic density on disc brake heating and cooling cycles. These intervals allowed for the identification of time-specific thermal patterns and hotspots that could affect braking efficiency. The use of two emissivity settings (0.95 and 0.35) enabled a comparative analysis of thermographic accuracy on oxidized versus reflective metallic surfaces. By capturing temperature data using a FLIR T640 infrared camera and supplementing it with environmental monitoring tools, this study provides valuable insights into how tropical climates and daily thermal fluctuations can impact the reliability and safety of disc brake systems in real-world automotive applications.

3.1 Excel Calculation Result

The analysis of disc brake temperatures across morning, afternoon, and evening sessions, comparing emissivity values of 0.35 and 0.95, clearly shows that emissivity has a significant impact on temperature readings in all conditions. In both scenarios with extreme temperatures (>160°C) and without extreme temperatures (<160°C) the lower emissivity value (0.35) consistently produced higher temperature results compared to the higher emissivity (0.95). This difference was especially noticeable during repeated breaks or in hotter environmental conditions, such as the afternoon and evening sessions, where temperature spikes and hotspots were more frequent. Even under normal temperature ranges, the temperature gap between the two emissivity settings remained evident. These findings highlight the importance of accurate emissivity calibration when using infrared thermography to evaluate brake performance, as incorrect settings can lead to overestimated temperatures and potentially false conclusions about brake safety and wear. Overall, the graphs summarize the complete temperature behavior of the disc brakes in real highway conditions and emphasize the value of IRT as a non-contact monitoring tool for both engineers and safety assessments, especially in hot climates like Malaysia.

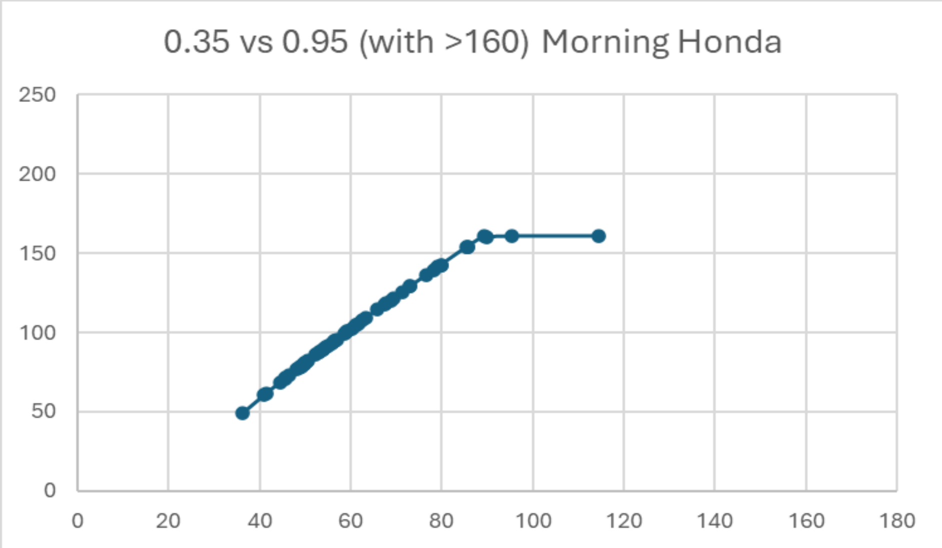

Fig 3 Morning Comparison of Emissivity 0.35 vs 0.95 with >160°C values

Figure 3 above presents a comparison of the disc brake temperature measurements for the morning session using two different emissivity values: 0.35 and 0.95. The results include temperatures exceeding 160°C, highlighting the presence of extreme thermal conditions. It was observed that the emissivity value of 0.35 consistently recorded higher temperature readings compared to the emissivity value of 0.95. This outcome aligns with the fundamental principle of infrared thermography, where lower emissivity values tend to amplify the measured surface temperature. The presence of hotspots, with some measurements surpassing 160°C, indicates instances of high thermal stress on the disc brake during morning driving conditions, particularly after repeated break near toll areas.

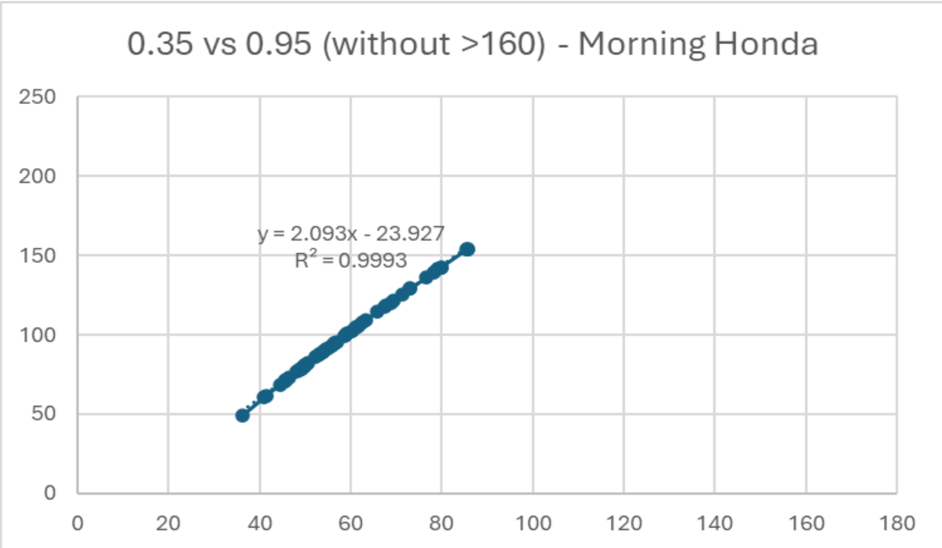

Fig 4 Morning Comparison of Emissivity 0.35 vs 0.95 without >160°C values

Figure 4 provides a comparative analysis of morning session temperatures after filtering out extreme values exceeding 160°C. By excluding these outliers, the analysis focuses on typical operating temperatures. The results show that while both emissivity values recorded lower overall temperatures, the emissivity of 0.35 continued to yield higher measurements than 0.95. This reinforces the importance of selecting an appropriate emissive value for accurate thermal assessment, particularly when monitoring routine braking events in cooler morning conditions.

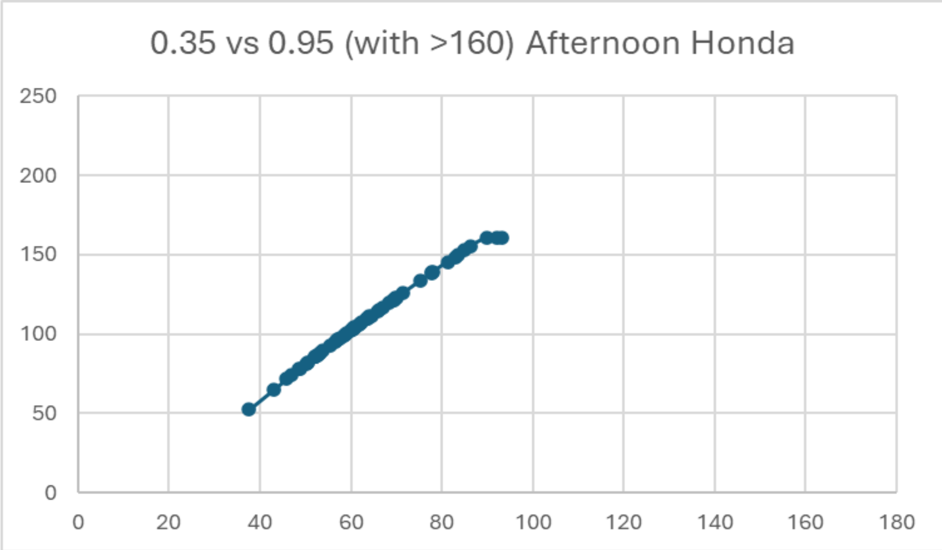

Fig 5 Afternoon Comparison of Emissivity 0.35 vs 0.95 with >160°C values

Figure 5 above illustrates the afternoon session disc brake temperature distribution under the same two emissive settings. This session recorded the highest overall temperatures among all time periods, with multiple instances of temperatures exceeding 160°C. The increased ambient temperature during the afternoon contributed to the elevated brake disc temperatures. Like the morning session, the emissivity value of 0.35 consistently produced higher readings than the 0.95 setting. The data suggest that in hotter environmental conditions, the disc brake system is more susceptible to reaching critical temperature levels, which may result in thermal stress and potential degradation of braking performance.

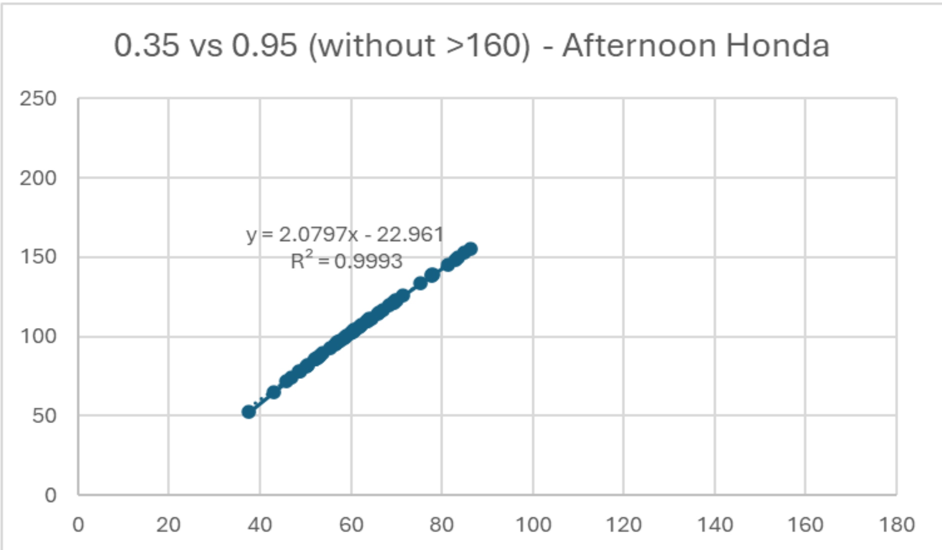

Fig 6 Afternoon Comparison of Emissivity 0.35 vs 0.95 without >160°C values

In Figure 6 the afternoon disc brake temperatures are presented after the exclusion of extreme values above 160°C. The afternoon session remained the warmest overall, with higher average temperatures even after filtering. The emissivity of 0.35 again produced consistently higher readings compared to 0.95, reflecting the impact of emissivity on the perceived temperature. These findings suggest that environmental heat and braking frequency during the afternoon contribute significantly to disc brake temperature, even when extreme cases are not considered.

Research Progress in Mechanical and Manufacturing Engineering Vol. 7 No. 1 (2026) p. 180-187

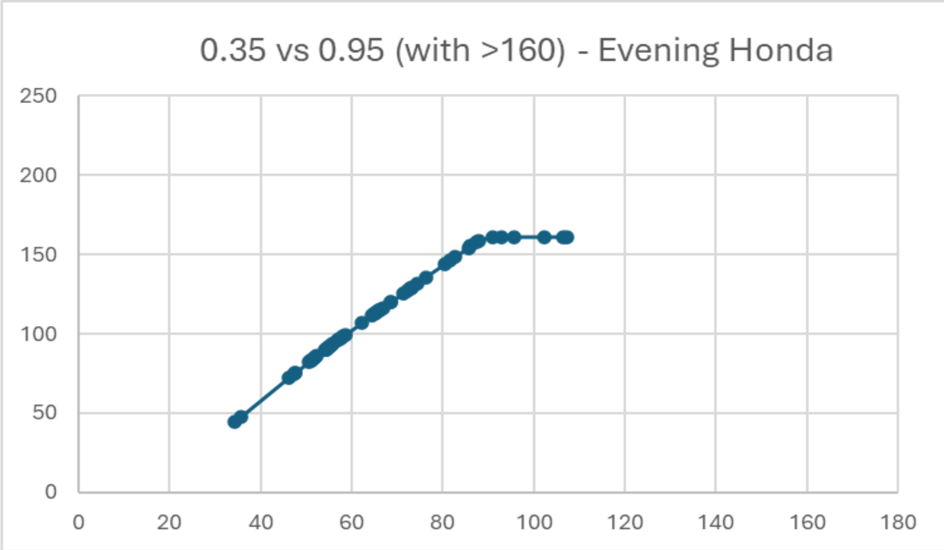

Fig 7 Evening Comparison of Emissivity 0.35 vs 0.95 with >160°C values

Figure 7 shows the temperature comparison for the evening session with the inclusion of extreme temperatures above 160°C. Although the ambient temperature is lower in the evening compared to the afternoon, some high-temperature readings persisted, particularly when using emissivity 0.35. The trend of higher temperature values with the lower emissivity setting was maintained, emphasizing the impact of emissivity calibration on thermal measurement accuracy. The data indicate that even during evening sessions, where environmental cooling occurs, thermal accumulation from prolonged or repeated braking can still lead to significant temperature elevations.

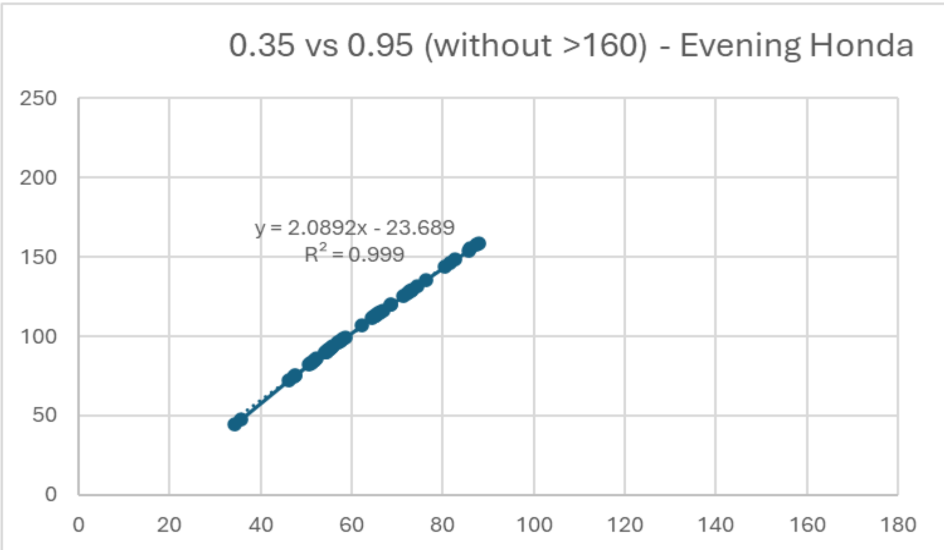

Fig 8 Evening Comparison of Emissivity 0.35 vs 0.95 without >160°C values

Figure 8 depicts the comparison of evening disc brake temperatures without including measurements above 160°C. As expected, the evening session demonstrated cooler temperature distributions relative to the afternoon session. However, the pattern of higher temperature readings with emissivity 0.35 persisted. The removal of extreme values allowed for a clearer understanding of the standard operating thermal behavior of the disc brake system during evening driving conditions, which appeared less thermally stressed than in earlier sessions.

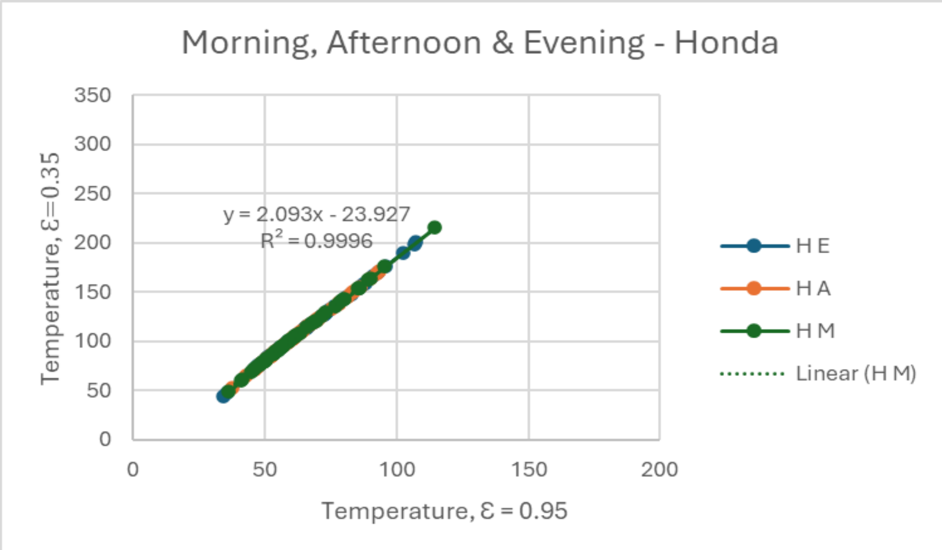

Fig 9 Summary of Disc Brake Temperatures at Emissivity 0.35 and 0.95 (Excluding >160°C) During Morning, Afternoon, and Evening Sessions

Across all session's morning, afternoon, and evening it is evident that emissivity plays a critical role in the interpretation of thermal data as depicted in Figure 9. The use of an emissive value of 0.35 consistently resulted in higher recorded temperatures compared to 0.95, regardless of the time of day or environmental conditions. Furthermore, when extreme temperatures above 160°C were excluded from the dataset, the overall temperature profiles remained lower but still demonstrated the same emissivity-related discrepancies. These findings highlight the necessity of precise emissivity calibration in infrared thermography applications for automotive brake temperature monitoring, particularly in hot climates such as Malaysia.

4. Conclusion

The analysis of disc brake temperature behaviour in imported Honda vehicles under real highway driving conditions using Infrared Thermography (IRT) has provided significant insights into the thermal dynamics of braking systems. The study confirmed that emissivity plays a crucial role in the accuracy of temperature measurements, with lower emissivity values (0.35) consistently recording higher surface temperatures compared to higher emissivity values (0.95). This effect was observed across all sessions: morning, afternoon, and evening, highlighting the need for precise emissivity calibration when employing thermal imaging for brake system analysis. Furthermore, the investigation revealed that environmental conditions, particularly ambient temperature and braking frequency, greatly influence the thermal behaviour of disc brakes. The afternoon sessions recorded the highest brake temperatures, indicating the compounded effect of elevated air temperatures and increased solar exposure. The formation of thermal hotspots observed in the thermal images raises concerns about the potential for uneven wear, brake fade, and compromised braking performance over time. The study also demonstrated that excluding extreme temperature outliers above 160°C provides a clearer understanding of typical operational temperature ranges, which can support more accurate thermal assessments for safety evaluations. Overall, the use of IRT proved to be an effective, non-invasive method for capturing real-time thermal profiles of disc brakes in actual driving conditions. These findings contribute to the ongoing development of safer and more reliable braking systems, particularly for vehicles operating in Malaysia's hot and humid climate. The research underscores the importance of integrating accurate thermal analysis into vehicle safety assessments and brake system design. Future studies are recommended to explore advanced materials, cooling techniques, and the long-term effects of thermal cycling on brake components to further enhance vehicle safety and performance.

Acknowledgement

The authors wish to thank the Faculty of Mechanical Engineering, Universiti Tun Hussein Onn Malaysia, who has supported the accomplishment of the research activity.

References

Journal

[1] Belhocine, A., & Bouchetara, M. (2012). "Thermal behavior of full and ventilated disc brakes of vehicles." *Journal of Mechanical Science and Technology.*
[2] Maniana, M., et al. (2022). "Heat transfer in a disk brake." *Institute of Electrical and Electronics Engineers Inc.*.
[3] Jafari, R., et al. (2021). "Experimental and numerical study of turbulent flow and thermal behavior of automotive brake disc under repetitive braking." *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering.*
[4] Mladenov, G. D., et al. (2022). "Integrated brake disc temperature measurement system." *AIP Conference Proceedings.*
[5] Kim, J. (2019). "Non-destructive characterization of railway materials and components with infrared thermography technique." *Materials.*
[6] Terziev, V., et al. (2021). "Monitoring of disk brakes vs drum brakes using infrared thermography." *2022 57th International Scientific Conference on Information, Communication and Energy Systems and Technologies (ICEST)*.
[7] Shin, H. J., et al. (2014). "A study on the nondestructive evaluation of carbon/carbon brake disks using infrared thermography." *Polymers and Polymer Composites.*
[8] Nicolescu, F., & Robescu, D. N. (2021). "Fault analysis for wastewater treatment plant equipment using thermography." *IOP Conference Series: Earth and Environmental Science.*
[9] Kim, J. G., et al. (2009). "Analysis of hot spots evolution on brake disc using high-speed infrared camera." *Key Engineering Materials.*
[10] Yan, H., et al. (2018). "Experimental study of convective heat transfer in standard and cross-drilled brake discs with radial vane and X-lattice cores." *International Mechanical Engineering Congress and Exposition*.
[11] Kim, J. G., et al. (2011). "Infrared thermographic analysis of railway brake disc during braking." *Key Engineering Materials.*
[12] Meng, D., et al. (2024). "Research on the evolution of friction hot spots in vehicle disc brake during braking based on experiment." *International Journal of Thermal Sciences.*
[13] Bryant, D., et al. (2011). "Brake judder – An investigation of the thermo-elastic and thermo-plastic effects during braking." *International Journal of Vehicle Structures and Systems.*
[14] Gang, W., et al. (2023). "Study on the influence of running parameters on the temperature field of disc brake on long downhill road." *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering.*
[15] Mogi, E., et al. (2012). "Study on contribution of driving stiffness to vehicle fuel economy." *SAE Technical Papers on CD-ROM / SAE Technical Paper Series*.