Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/

e-ISSN : 2964-2647

THERMAL AND GEOMETRIC CHARACTERIZATION OF A PLASMA TORCH: A STUDY ON THE EFFECT OF ELECTRICAL CURRENT VARIATION

Ahmad Fati'in[1)], Sunaryo[2*)], Heru Nugroho[3)]
Universitas Sains Al-Qur'an, Indonesia
[1)]a.fatiin@gmail.com, [2)]sunaryo@unsiq.ac.id, [3)]suheru.st@gmail.com

*sunaryo@unsiq.ac.id

Submitted : 2 Oct 26 | **Accepted** : 20 Oct 26 | **Published** : 30 Oct 2026

Abstract:
Plasma gasification is a technology that utilizes high plasma energy to convert organic and inorganic materials into syngas. In hot plasma gasification, a plasma torch heats and decomposes waste into synthetic gas (syngas). This study is expected to improve understanding of efficient and effective plasma gasification operating parameters. The experimental method in this study uses variations of DC electric currents of 30 A, 40 A, 50 A, and 60 A, with three replicates conducted for each experimental condition at a constant operating pressure of 5 bar and a gas flow rate of 21 L/min. The highest arc length and temperature were obtained at 60A with argon as the plasma gas (20 mm, 563.67°C) and with air as the plasma gas (25 mm, 215°C). Electric current and plasma gas type can affect the efficiency of gasification using a plasma torch; higher electric current increases arc length and temperature. Air can be used as a plasma gas alternative to other plasma gases. This research can serve as a reference for developing gasification technology using a plasma torch.

Keywords: *Gasification; Plasma torch; Electric current; Plasma thermal*

1. Introduction

Plasma gasification is a high-temperature conversion technology that utilizes the intense energy generated by plasma to convert organic and inorganic materials into synthesis gas (syngas) and other energy-related products. This technology has been widely investigated for waste treatment, energy recovery, and chemical production. Plasma is an ionized state of matter characterized by extremely high temperatures, enabling chemical bonds to be broken efficiently. In plasma gasification, the heat generated by a plasma torch is used to heat and decompose feedstock, particularly waste materials, into gaseous products. This process offers the potential to convert various types of waste into useful forms of energy through thermochemical conversion. A wide range of feedstocks, including industrial waste, medical waste, municipal solid waste, coal, and biomass, can be converted into syngas consisting primarily of CO, H_2, and CO_2. The resulting syngas can subsequently be utilised as a fuel for combustion systems, electricity generation, or hydrogen production

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/
e-ISSN : 2964-2647

(Sanlisoy & Carpinlioglu, 2017). Plasma gasification has also been investigated for peat, municipal solid waste, and Indonesian low-rank coal, illustrating the applicability of plasma-assisted conversion to different feedstocks (Lazar et al., 2012; Sesotyo et al., 2019; Sesotyo et al., 2021).

The plasma arc is a key component of a plasma gasification system because it generates high-intensity thermal energy through an electrical discharge, providing the temperatures required for the gasification process. Several operating parameters, including electrical current, arc length, and heat distribution, strongly influence plasma arc performance and consequently affect the efficiency and effectiveness of the gasification process. Plasma arcs can generate extremely high temperatures, enabling the thermal decomposition of both organic and inorganic waste while potentially minimising the formation of undesirable by-products. Plasma itself can be described as a high-temperature stream of ionised gas, with temperatures reaching approximately 10,000 °C, produced by an electrical discharge that commonly forms an arc within a plasma torch. The device in which the electrodes are installed is referred to as a plasma torch, and the electrodes are typically made of copper, carbon, or other materials capable of withstanding severe thermal conditions. Previous studies have explained that plasma processes involve the dissociation and degradation of matter at the molecular and atomic levels. When applied to organic materials such as waste or biomass in the presence of a gasifying or oxidising agent, including air, oxygen, or steam, the energy supplied by the plasma provides the high temperatures required to drive the thermochemical reactions involved in the gasification process (Molino et al., 2016). Fundamental plasma phenomena and their applications are discussed by Nur (2011), while experimental characteristics of argon plasma jets at atmospheric pressure have been reported by Kinandana et al. (2015).

Electrical current is one of the key operating parameters that affects the characteristics of a plasma arc, including arc length and the temperature generated. Variations in current can alter the arc temperature, arc length, and thermal intensity, which in turn influence the overall efficiency of the gasification process. In general, an increase in electrical current is associated with a higher energy input to the plasma arc. However, the specific effects of current variation on arc length and heat distribution still require further investigation, particularly in plasma gasification applications. Shie et al. (2014) investigated the gasification of a mixture of municipal solid waste and raw wood (MSW/RW) that had undergone steam mechanical heat treatment (SMHT) as a pretreatment process. The resulting material was used as the target feedstock in a plasmatron reactor equipped with a plasma torch operating at 10 kW. The study reported that syngas, primarily consisting of CO and H_2, accounted for nearly 90% of the gaseous products within approximately two minutes of reaction time, indicating a relatively high reaction rate. The syngas yield ranged from 88.59% to 91.84%. In another study, Tamošiūnas et al. (2023) investigated biomass gasification using wood pellets in a direct-current thermal plasma arc system operated at atmospheric pressure. The reported carbon conversion efficiency and energy conversion efficiency were 100% and 48.83%, respectively, while the production of 1 kg of syngas required an electrical energy input of approximately 1.78 kWh. Related studies have also examined the effect of electrical current on plasma arcs in medical-waste gasification (Gibraltarq, 2023) and simulated arc plasma gasification under experimental conditions (Cao et al., 2020).

Plasma arc length is closely related to the amount of energy contained within the arc. A longer arc can provide a larger heating zone and increase the potential for heat transfer to the gasification feedstock. Therefore, variations in arc length may significantly influence heat distribution and, consequently, the efficiency of the gasification process. If the arc is too short, thermal energy may not be distributed uniformly across the reaction zone. Conversely, an excessively long arc may increase the possibility of heat losses to the surrounding environment. For this reason, achieving an appropriate arc length is essential for maintaining effective and stable heat transfer during plasma gasification.

Optimizing plasma arc performance in a gasification system is a complex task because several operating parameters must be considered simultaneously, including electrical current, plasma gas composition, temperature, and pressure. The present study focuses on the use of a direct-current power source to investigate the effect of electrical current variation on plasma arc length and plasma torch temperature. Air and argon are

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/
e-ISSN : 2964-2647

employed as plasma gases to examine the influence of gas type on the resulting thermal and geometric characteristics of the plasma arc. These parameters are important because appropriate control of current and plasma gas conditions may contribute to improved energy transfer and greater gasification efficiency. Accordingly, this study aims to determine how variations in electrical current affect plasma arc characteristics, particularly arc length and plasma torch temperature, and to provide a basis for improving plasma system performance in gasification applications.

Plasma gasification has attracted increasing attention in waste treatment and energy recovery because of its ability to process a wide range of waste materials while potentially reducing the formation of conventional pollutants. Nevertheless, improving its efficiency and reducing operational costs require a clearer understanding of the relationships among the main operating parameters, particularly electrical current and plasma gas type. A detailed understanding of these parameters is therefore essential for determining how current regulation influences plasma arc length, thermal characteristics, and energy transfer within the plasma torch, as well as how these changes may affect the overall gasification process. In Indonesia, the potential conversion of municipal solid waste into electrical energy using plasma gasification has also been evaluated (Usmadiansyah, 2017).

Although previous studies have investigated plasma gasification technology and the influence of operating parameters on plasma behavior, a direct comparison of air and argon under identical electrical current conditions remains important for understanding their different plasma characteristics. Air and argon have distinct physical and thermophysical properties that may influence arc formation, arc length, and plasma temperature. Therefore, comparing these gases at the same current levels provides a consistent basis for evaluating their responses to changes in electrical input while minimizing differences in experimental operating conditions. This study experimentally investigates the effects of DC electric current (30, 40, 50, and 60 A) and plasma gas type (air and argon) on plasma arc length and temperature under controlled operating conditions. The specific contribution of this research is a comparative characterization of air- and argon-based plasma torches, highlighting differences in arc length, temperature, and their responses to increasing current. The findings provide experimental evidence to support the selection of plasma gases and operating currents for plasma torch development. However, the study focuses exclusively on plasma torch characteristics and does not directly evaluate gasification efficiency, syngas production, or waste-treatment performance.

2. RESEARCH METHODS

This study employed an experimental testing method to investigate the cause-and-effect relationships among several interrelated factors. The main experimental variable was the electrical current, which was varied at 30 A, 40 A, 50 A, and 60 A. Air and argon were used as the plasma gases, while the gas supply pressure was maintained constant at 5 bar and flow rate of 21 L/min throughout the experiments.

Prior to the main experimental measurements, an initial performance test (pre-test) of the plasma torch was conducted to verify the functionality and operational readiness of the system. The testing procedure involved assembling the electrical system, consisting of an inverter and a high-voltage driver, connecting it to the electrodes, and installing the argon gas supply at a pressure of 5 bar and flow rate of 21 L/min. After the system was activated, its successful operation was confirmed through visual observation of the plasma arc. The formation of a stable plasma arc indicated that the plasma torch system was functioning properly and was ready for subsequent experimental data collection.

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/
e-ISSN : 2964-2647

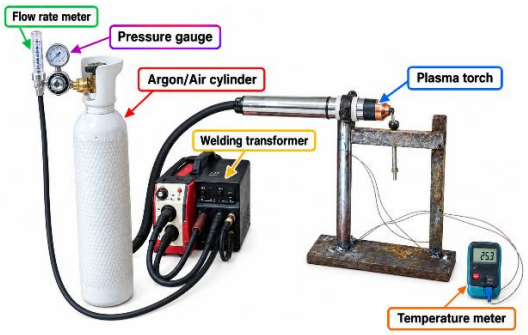


Figure 1. Plasma Torch Experimental Setup

The plasma torch experiment was designed to investigate the effect of electrical current variation on plasma arc length and temperature during the gasification process, using air and argon as the plasma gases at a constant pressure of 5 bar. The experiment was conducted in two main stages according to the type of plasma gas employed. Stage I used air as the plasma gas, while Stage II used argon, with three experimental replicates performed for each stage. The electrical current was varied at four levels: 30 A, 40 A, 50 A, and 60 A.

For each combination of experimental conditions, the plasma arc length was measured manually using a steel ruler and recorded in millimeters (mm). Plasma temperature was measured using a thermocouple connected to a digital multimeter and recorded in degrees Celsius (°C). All measurements were conducted systematically to obtain empirical data for evaluating the performance characteristics and identifying the optimal operating conditions of the plasma torch. The experimental setup used in this study is illustrated in Figure 1. Thermocouple calibration procedures in experimental measurement systems have been documented by Mariam et al. (2013).

3. RESULTS AND DISCUSSION

The experimental results demonstrate that electrical current has a clear influence on both the geometric and thermal characteristics of the plasma arc. Under a constant gas pressure of 5 bar and a gas flow rate of 21 L/min, increasing the current from 30 A to 60 A consistently increased the plasma arc length for both air and argon. Based on the three experimental replicates, the mean arc length obtained with air increased from 10.0 mm at 30 A to 15.0 mm at 40 A, 20.0 mm at 50 A, and 23.67 mm at 60 A. In comparison, the corresponding mean arc lengths for argon were 10.0, 15.0, 17.0, and 20.0 mm, respectively. These results indicate that a higher electrical current promotes the formation of a longer plasma arc, although the magnitude of the increase depends on the type of plasma gas used.

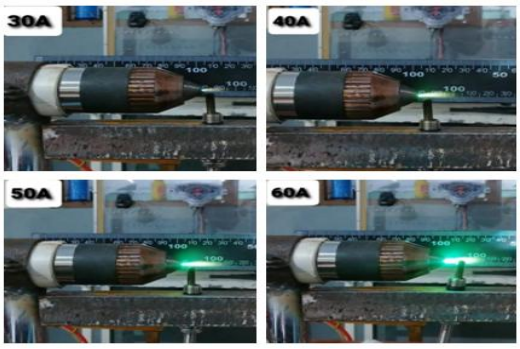


Figure 2. Visual results of plasma arc length at current variations of 30 A, 40 A, 50 A, and 60 A using air as the plasma gas.

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/
e-ISSN : 2964-2647

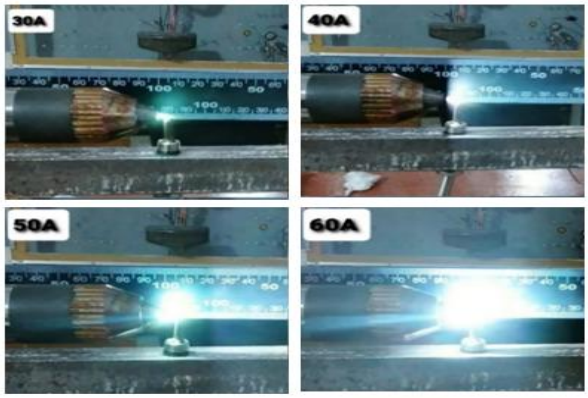


Figure 3. Visual results of plasma arc length at current variations of 30 A, 40 A, 50 A, and 60 A using argon as the plasma gas.

Figures 2 and Figure 3 provide visual confirmation of the experimental results. The images show that the visible plasma arc became more pronounced as the electrical current increased from 30 A to 60 A. The visual observations are consistent with the measured values, indicating that higher current enhanced arc development for both plasma gases. In addition, the comparison between the two figure panels supports the quantitative finding that air tended to produce a longer visible arc, whereas argon produced a more concentrated and thermally intense discharge, especially at higher current levels.

The increase in arc length can be associated with the greater electrical energy supplied to the discharge as the current increases. A higher current strengthens the ionization process and allows the conductive plasma channel to be maintained over a greater distance between the electrodes. However, different responses were observed between air and argon. Air produced a longer arc, particularly at currents of 50 and 60 A, whereas argon produced a shorter but highly repeatable arc length across all three replicates. At 60 A, the average arc length was approximately 23.67 mm for air compared with 20.0 mm for argon. The identical arc-length measurements obtained in the three argon tests also suggest that the argon plasma produced a more geometrically stable discharge under the investigated operating conditions. In contrast, some variation was observed for air at 60 A. This difference indicates that plasma gas composition plays an important role in determining arc development and stability. Figure 4 summarizes the relationship between electrical current and mean plasma arc length for both gases.

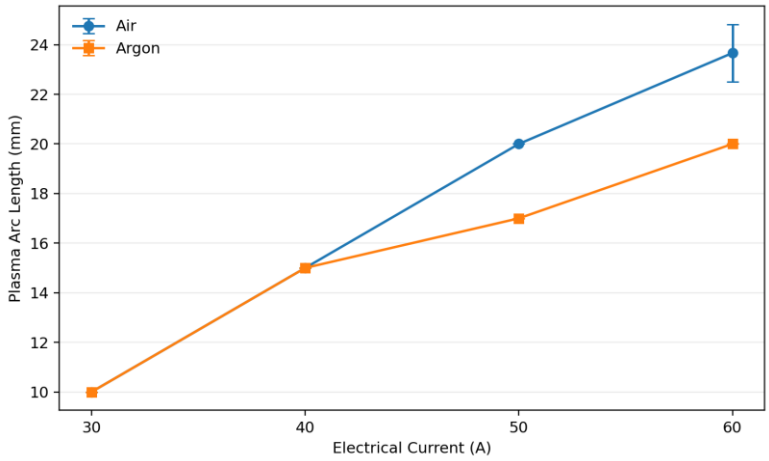


Figure 4. Effect of current on plasma arc length for air and argon

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/
e-ISSN : 2964-2647

A stronger effect of electrical current was observed in the thermal characteristics of the plasma torch. For air, the mean measured temperature increased from 91.0 °C at 30 A to 170.0 °C at 40 A, 183.67 °C at 50 A, and 213.33 °C at 60 A. Thus, increasing the current from 30 to 60 A resulted in an approximately 134% increase in the measured temperature. Argon exhibited a substantially different thermal response. The mean temperatures were 81.67 °C, 234.67 °C, 301.33 °C, and 563.67 °C at 30, 40, 50, and 60 A, respectively. Consequently, the measured temperature at 60 A was almost seven times that recorded at 30 A. The most pronounced increase occurred between 50 and 60 A, indicating a nonlinear thermal response of the argon plasma at higher current levels (Figure 5).

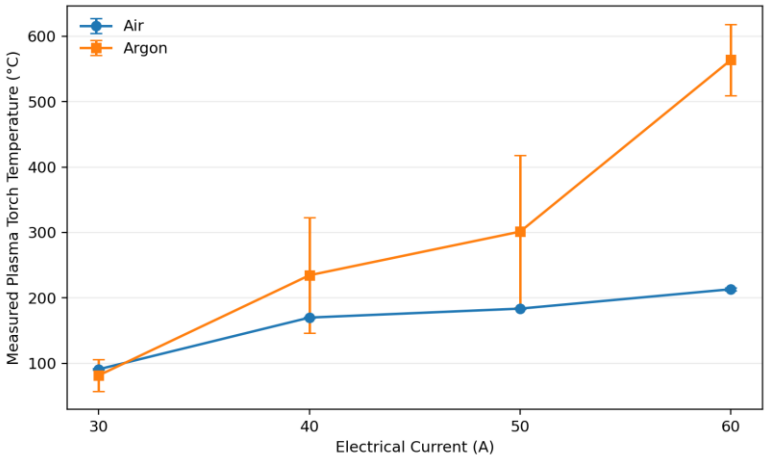


Figure 5. Effect of current on plasma torch temperature for air and argon

An interesting feature of these results is the contrasting behavior of arc length and temperature for the two gases. Air generally produced a longer plasma arc, whereas argon generated a considerably higher temperature at medium-to-high current levels. At 30 A, the average temperature obtained with argon was approximately 9.3 °C lower than that obtained with air. However, at 40, 50, and 60 A, the average argon temperatures exceeded those of air by approximately 64.7, 117.7, and 350.3 °C, respectively. This finding suggests that a longer arc does not necessarily correspond to a higher measured temperature. Instead, the thermal behavior of the plasma torch is determined by the combined effects of electrical input, plasma gas properties, ionization behavior, and arc stability. Argon, as an inert plasma gas, appears to provide a more stable discharge and becomes particularly effective in generating higher thermal intensity as the electrical current increases. Air, on the other hand, favors greater arc extension but produces a comparatively lower temperature within the operating range investigated.

The relationship observed between electrical input and plasma temperature is generally consistent with previous plasma gasification studies. Ismail et al. (2019) reported that increasing plasma power resulted in an increase in plasma and gasification reactor temperatures, emphasizing temperature as an important parameter affecting gasification performance and syngas quality. Although the present study varied electrical current rather than total plasma power, the observed trend follows a similar physical response: increasing the electrical energy supplied to the plasma system increases its thermal output. Nevertheless, direct quantitative comparison with previous studies should be made cautiously because plasma torch design, voltage, plasma gas composition, gas flow rate, reactor configuration, and temperature measurement methods may differ substantially among experimental systems.

The temperature measurements in this study should also be interpreted according to the measurement method employed. The maximum recorded temperature was approximately 563.67 °C in an individual argon test at 60 A, whereas plasma gasification systems reported in the literature can operate at substantially higher

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/
e-ISSN : 2964-2647

plasma or reactor temperatures. Messerle and Ustimenko (2024), for example, reported plasma gasification operating temperatures over a considerably broader and higher temperature range. Therefore, the thermocouple measurements obtained in the present experiment should be regarded primarily as the local temperature detected at the specified measurement position rather than as the absolute temperature of the plasma arc core. The plasma core may reach temperatures substantially higher than those directly recorded by the thermocouple. Future studies would benefit from complementary non-contact temperature measurement techniques, such as optical pyrometry or spectroscopic diagnostics, particularly when the actual plasma core temperature is required.

The constant gas flow rate of 21 L/min also provides useful information regarding the operational requirements of the plasma torch. Under the assumptions adopted in this study, an argon cylinder with an equivalent gas capacity of 1 m^3 and a supply pressure of 5 bar was estimated to provide approximately 234.95 min of operation. This estimate is useful for assessing gas consumption and planning continuous plasma torch operation. However, gas consumption should not be interpreted directly as gasification efficiency. A comprehensive assessment of plasma gasification efficiency would additionally require measurements of electrical power consumption, feedstock conversion rate, syngas yield and composition, cold gas efficiency, and overall energy conversion efficiency. Thus, the present results primarily characterize the geometric and thermal performance of the plasma torch rather than the complete energy efficiency of the gasification system.

Overall, the results confirm that electrical current and plasma gas type are important operating parameters governing plasma torch characteristics. Increasing the electrical current from 30 to 60 A increased both arc length and temperature, but the magnitude and pattern of these changes differed between air and argon. Air produced a relatively longer arc, whereas argon provided a more stable arc length and substantially higher temperatures at higher currents. Among the tested conditions, the combination of argon and 60 A produced the highest measured thermal output, while air at 60 A produced the longest average arc. These findings indicate that the appropriate operating condition should be selected according to the thermal and geometric requirements of the gasification reactor rather than solely on the basis of maximum current. The results therefore provide an experimental basis for further optimization of plasma torch operation, particularly through simultaneous consideration of current, plasma gas type, arc stability, temperature, electrical power consumption, and syngas production performance.

Table 1. Summary of mean experimental values (n = 3)

Current (A)	Air arc (mm)	Argon arc (mm)	Air temp. (°C)	Argon temp. (°C)
30	10.00	10.00	91.00	81.67
40	15.00	15.00	170.00	234.67
50	20.00	17.00	183.67	301.33
60	23.67	20.00	213.33	563.67

Data note: For the air test at 60 A, the arc-length values used in the calculations follow the tabulated data (23, 25, and 23 mm), because the source narrative contains inconsistent values for Tests 1 and 3.

4. CONCLUSIONS

This study investigated the effects of electrical current and plasma gas type on the arc length and measured temperature of a plasma torch under controlled operating conditions. The experimental results showed that increasing the electrical current from 30 A to 60 A was generally associated with increases in arc length and temperature for both air and argon at a constant gas pressure of 5 bar and a gas flow rate of 21 L/min. However, the temperature response was not uniform across all current intervals, particularly for air between 40 A and 50 A, where the temperature increase was relatively small. These findings indicate that electrical current and plasma gas type influence the observed geometric and thermal characteristics of the plasma torch within the investigated operating range.

The two plasma gases exhibited different characteristics. Air produced longer plasma arcs, whereas argon generally exhibited higher measured temperatures, particularly at higher current levels. At 60 A, argon reached

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

the highest individual temperature measurement of 563.67 °C. Thus, 60 A represented the condition with the highest measured temperature within the tested range, rather than an optimum operating condition. Furthermore, the reported temperatures represent measurements at the experimental measurement location and should not be interpreted as the overall plasma temperature or total thermal energy output.

The present study was limited to the experimental characterization of plasma arc length and local temperature. Feedstock conversion, syngas yield and composition, electrical power consumption, and overall energy efficiency were not measured. Therefore, the results cannot establish improvements in gasification efficiency or waste-treatment performance. Future research should integrate plasma torch characterization with direct measurements of electrical power and energy consumption, long-term arc stability, feedstock conversion, and syngas production under actual gasification conditions. Such investigations are necessary to evaluate the relationship between plasma torch operating parameters, energy requirements, and gasification performance, and to identify operating conditions that provide an appropriate balance between thermal characteristics, operational stability, and energy efficiency.

5. REFERENCES

Cao, Y., Li, B., Wang, Q., Zhang, Z., & Han, X. (2020). Simulation of arc plasma gasification based on experimental conditions. *E3S Web of Conferences*, 194, 05029. https://doi.org/10.1051/e3sconf/202019405029

Gibraltar, M. (2023). Pengaruh kuat arus terhadap busur plasma dan konsentrasi gas CO pada gasifikasi sampah medis menggunakan tungku plasma [Diploma thesis, Universitas Andalas]. http://scholar.unand.ac.id/id/eprint/205892

Ismail, T. M., Ramos, A., Abd El-Salam, M., Monteiro, E., & Rouboa, A. (2019). Plasma fixed bed gasification using an Eulerian model. *International Journal of Hydrogen Energy*, 44(54), 28668-28684. https://doi.org/10.1016/j.ijhydene.2019.08.035

Kinandana, A. W., Nur, M., & Muhlisin, Z. (2015). Karakteristik plasma jet argon menggunakan kolom dielectric barrier discharge (DBD) pada tekanan atmosfer. *Youngster Physics Journal*, 4(4), 273-278. http:// https://ejournal3.undip.ac.id/index.php/bfd/article/view/9404.

Lazar, M., Lengyelova, M., & Kurilla, P. (2012). Experiment of peat gasification in plasma reactor, *The Holistic Approach to Environment*, 2(4), 177-186. https://hrcak.srce.hr/file/137705

Mariam, S., Pribadi, K., Bambang, G. H., Rosidi, A., & Juarsa, M. (2013). Kalibrasi termokopel tipe-K pada bagian uji HeaTing-03 menggunakan cDAQ-9188. *Sigma Epsilon*, 17(4), 160-168. https://doi.org/10.17146/SIGMA.2013.17.4.2112

Messerle, V., & Ustimenko, A. (2024). Plasma processing of rubber powder from end-of-life tires: Numerical analysis and experiment processes. *Processes*, 12, 994. https://doi.org/10.3390/pr12050994

Molino, A., Chianese, S., & Musmarra, D. (2016). Biomass gasification technology: The state of the art overview. *Journal of Energy Chemistry*, 25(1), 10-25. https://doi.org/10.1016/j.jechem.2015.11.005

Nur, M. (2011). Fisika plasma dan aplikasinya. Universitas Diponegoro. http://eprints.undip.ac.id/42899

Sanlisoy, A., & Carpinlioglu, M. O. (2017). A review on plasma gasification for solid waste disposal. *International Journal of Hydrogen Energy*, 42(2), 1361-1365. https://doi.org/10.1016/j.ijhydene.2016.06.008

Sesotyo, P. A., Nur, M., & Suseno, J. E. (2019). Plasma gasification modeling of municipal solid waste from Jatibarang Landfill in Semarang, Indonesia: Analyzing its performance parameters for energy potential. *E3S Web of Conferences*, 125, 14009. https://doi.org/10.1051/e3sconf/201912514009

Sesotyo, P. A., Nur, M., & Muraza, O. (2021). Analysis of potential energy and environmental impact from coal gasification through simulation of plasma gasification process of Indonesian low-rank coal. *Indonesian Mining Journal*, 24(1), 57-70. DOI: 10.30556/imj.Vol24.No1.2021.1192

Shie, J. L., Chen, L. X., Lin, K. L., & Chang, C. Y. (2014). Plasmatron gasification of biomass lignocellulosic waste materials derived from municipal solid waste. *Energy*, 66, 82-89. https://doi.org/10.1016/j.energy.2013.12.042

Tamošiūnas, A., Gimžauskaitė, D., Aikas, M., Uscila, R., Snapkauskienė, V., Zakarauskas, K., & Praspaliauskas, M. (2023). Biomass gasification to syngas in thermal water vapor arc discharge plasma, *Biomass Conversion and Biorefinery*, 13(18), 16373-17384. https://doi.org/10.1007/s13399-023-03828-3

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clean Energy and Smart Technology
Volume 05, Number 01, October 2026
DOI : https://doi.org/10.58641/
e-ISSN : 2964-2647

Usmadiansyah (2017). Kajian konversi potensi sampah Kota Pontianak menjadi energi listrik dengan gasifikasi plasma, *Jurnal ELKHA*, 9(1), 28-33. DOI: 10.26418/elkha.v9i1.21495

This is an Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.