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ENHANCE THE HEAT AND FLAME CHARACTERISTICS OF SAGO BRIQUETTES WITH AND WITHOUT ADJUSTERS

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ABSTRACT

The researchers conducted experiments to evaluate how the introduction of a modifier affected the heating efficiency and stability of the flame in sago waste briquettes. The adjuster was used to maintain a constant distance during burning, which improved the combustion heat of the fuel. Infrared thermometry was used to monitor the temperature changes within the briquette and the combustion load represented by water in a pan. The results show that adding an effective adjuster significantly enhances the performance of both the briquettes and the stove, leading to improved effectiveness and efficiency. This is evident from the higher combustion temperature and faster boiling time of the water. The consistent burning distance ensures a stable and even supply of heat to the briquettes, enabling more efficient utilization of the fuel as all parts of the fuel can fully burn and transfer heat to the pan. Molecular analysis indicates that the stability of the burning distance weakens the Van der Waals bonds within the carbon chain, resulting in increased reactivity of the fuel molecules. As a result, the fuel exhibits improved ability to absorb heat and becomes highly flammable.

Keywords: Heat, flame characteristics, sago waste, briquettes

INTRODUCTION

The depletion of global energy reserves and the escalating energy demand, coupled with population growth, have rendered the energy crisis a pressing issue [1]. As a result, it is crucial to prioritize alternative fuel sources in order to improve energy security [2]. Biomass briquette fuel has emerged as a practical substitute, with researchers exploring different types of briquettes such as those made from sawdust and charred palm kernel, charcoal particles and sawdust agglomerates, vegetable market waste and sawdust, palm kernel shells, among others [3]–[5].

Simultaneously, research and development efforts have been directed towards briquette stoves [6]. The primary objective of these endeavors is to achieve high combustion efficiency. Key factors influencing the stove's performance encompass duration of combustion, temperature of the flame, quality of the air used for combustion, and differences in the openings for air intake [7].

Moreover, ensuring heat and flame stability assumes paramount importance. Consequently, several studies have been conducted, yielding efficiency levels ranging from 24% to 33% with varying heating values [8]. Unfortunately, these investigations have highlighted suboptimal heat generation from briquette combustion [9]. This discrepancy can be attributed to the inconsistent and variable burning distance between the briquette flame and the object being burned.

Consequently, research has been undertaken to establish the distance at which the flame comes into contact and the elevation of the gas burner as means of maintaining a consistent burning distance [10]. Nonetheless, these findings have indicated that shorter burner distances lead to the production of exhaust gases and inefficient combustion, while higher burners compromise stove efficiency due to increased flame-object distance [11].

Based on the aforementioned review, it becomes evident that the fluctuating is a significant factor contributing to reduced stove efficiency and briquette fuel performance.

Nevertheless, existing research on briquette stove improvement has predominantly focused on stove performance and practical applications, failing to unveil fundamental scientific insights. The distinct properties of carbon atoms and the intricacies of chemical processes pose challenges in comprehending their influence on briquette combustion performance using conventional research methods [12]. The arrangement of carbon atoms at a molecular level has the ability to improve the transfer of heat in a flame. Furthermore, the makeup and compactness of carbon atoms render them efficient conductors of heat, enabling fuel molecules composed of carbon atoms arranged in a single-layered allotrope structure (see Fig. 1) to become reactive and combustible. This phenomenon is similar with previous studies with described in different perspective [13], [14].

Considering the crucial scientific understanding of the burning distance and the role played by carbon atoms in the combustion process, it is imperative to conduct comprehensive and meticulous research encompassing detailed observations and analysis.

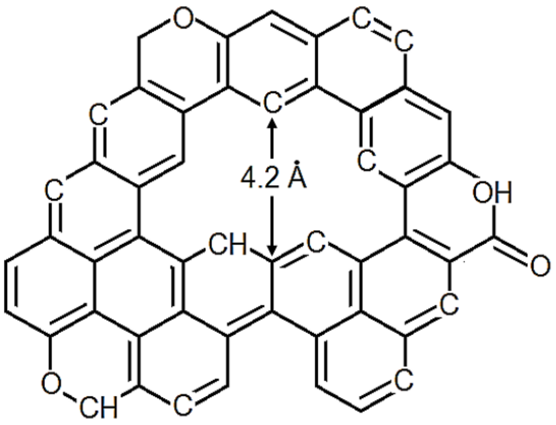

Figure 1. Molecular structure of charcoal

MATERIAL AND METHOD

The primary component utilized in the production of briquette fuel involves the conversion of sago waste into honeycomb-shaped briquettes. These briquettes have a diameter of 20 cm and a height of 11 cm, featuring 14 holes (refer to Fig. 2). The development of a briquette stove, as illustrated in Figure 3, incorporates the addition of an adjuster to keep a consistent combustion space of approximately 5 cm.

Figure 4 illustrates the experimental arrangement. During the initial stage, the briquettes are ignited and left to burn until they are entirely quelled. Subsequently, in the second phase, the briquettes are used to boil water, with temperature measurements being taken every 30 minutes using an infrared thermometer. Throughout the water heating process, the adjuster is employed to ensure that the burning distance remains constant at 5 cm.

The temperature measurements obtained during the phase of heating the water, the measurements involved capturing the temperature of the top surface of the briquette (T1) and the temperature at the bottom of the pan (T2).

Figure 2. Research material (Sago briquette)

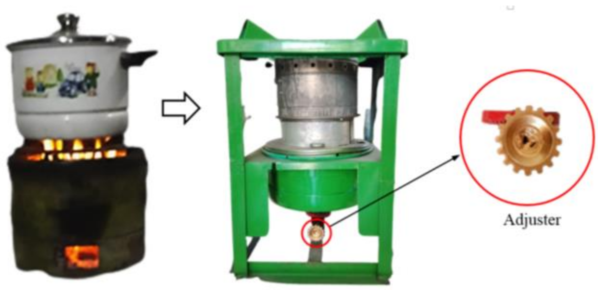

Figure 3. Experimental apparatus

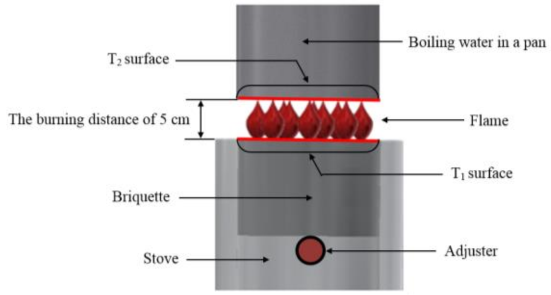

Figure 4. Research design

RESULT AND DISCUSSION

Based on the observations depicted in Figure 5, it is apparent that the absence of the adjuster leads to a smaller, opaque, and uneven flame compared to the flame produced by the stove with the adjuster (as shown in Figure 6). The flame produced by the stove with the adjuster is larger, brighter, and all 14 briquette holes emit flames. This observation strongly suggests that a stove equipped with an adjuster outperforms one without, demonstrating its superior performance. Additionally, the brighter and more powerful flame suggests increased reactivity of the fuel molecules, enabling easy heat absorption and ignition. Overall, the flame's burning time remains stable and constant for 210 minutes, indicating the positive impact of incorporating an adjuster. This stability in burning distance significantly influences the efficiency of both the fuel and the stove.

However, the use of an adjuster enhances the efficiency of briquette utilization by maintaining a consistent burning distance. In such cases, the flame from the briquette does not make direct contact with the pan's bottom. Allowing this situation to persist would result in inefficient and ineffective heat transfer to the water in the pan. Therefore, it is crucial to maintain a constant burning distance to ensure the pan receives and maintains optimal heat transfer.

Figure 5. Flame characteristics without adjuster

Figure 6. Flame characteristics with adjuster

This scenario is highly plausible as illustrated by Figure 7 and Figure 8, which indicate a general trend. The stove utilizing the adjuster demonstrates an increasing temperature in both measured parts: the temperature measurements were taken on the upper surface of the briquette (T1) and the lower surface of the pan (T2). In contrast, the stove lacking an adjuster shows a consistent decrease in temperature, beginning at the 60th minute for T1 and the 90th minute for T2.

Moreover, Figure 7 reveals that when the adjuster is employed, the briquette temperature reaches 525°C at the 30th minute and continues to rise. Furthermore, at the 150th minute, a temperature variation is observed, manifested by a drop to 731°C, followed by an increase to a maximum temperature of approximately 825°C at the 180th minute. On the other hand, without the adjuster, the temperature shows an increase from 520°C at the beginning of the combustion process, reaching a peak of around 625°C at 90 minutes, followed by a decline to 550°C.

These observations further support the notion that the adjuster positively influences the temperature behavior and stability of the briquette during combustion. The adjuster allows for enhanced control and maintenance of optimal temperatures, contributing to improved efficiency and performance of the stove. This analysis concurs with previous studies from various perspectives [15].

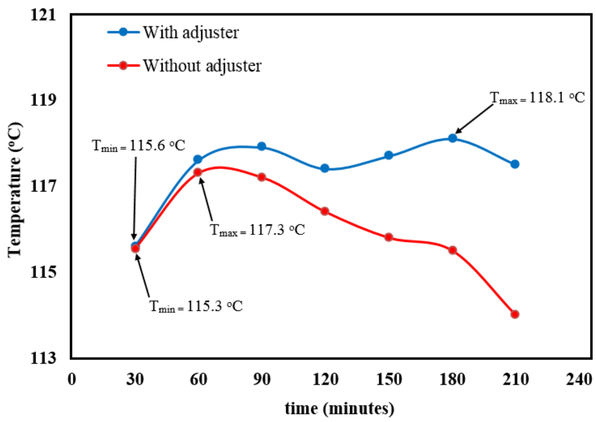

Figure 7. Temperature evolution of the briquette (T_1)

However, Figure 8 can observe a similar phenomenon. When using modifier, the temperature consistently increases from the 30th minute onwards, except for a decrease at 120 minutes when it reaches 117 °C. Eventually, it reaches a top heat of approximately 118 °C around 180 minutes. On the other hand, when using the stove without an adjuster, the temperature increases from 115.7 °C to 117.3 °C between 0 and 60 minutes. However, from minutes 90 to 210, the temperature gradually decreases and reaches 114 °C.

These findings suggest that applying the adjuster every 30 minutes throughout the entire combustion time may not be suitable due to the potential reduction in fuel performance. This phenomenon is plausible due to the briquettes accumulate heat differently, leading to potential depletion of the bottom part at varying times. With longer burning time, the briquettes receive more heat, causing the bottom part to burn and deplete faster. Nonetheless, overall, using the adjuster has been found to enhance the fuel and stove performance, as demonstrated by boiling 5 liters of water in approximately 11.4 minutes.

From a molecular perspective, the molecular structure of briquette fuel consists of carbon chains that resemble graphene. This indicates that the carbon chain's molecular structure acts as an efficient conductor, facilitating proper heat flow within the briquette. Moreover, the Van der Waals bonding strength among the carbon chains enhances the reactivity of the fuel molecules, rendering the fuel highly combustible. This analysis corresponds to previous research that investigated the use of crude vegetable oil as a fuel source [16].

This can be attributed to the weak nature of the dispersion bonding, causing the carbon chains to vibrate and collide when the briquette fuel is heated. Consequently, the density decreases. This phenomena concurs with previous studies from various perspectives [17], [18]. When the gap between the carbon chains increases, the Van der Waals bonds become less strong. Moreover, as the carbon atoms expand, the electrons gain greater reactivity, as they have more space to move and become excited [19]. This finding is reinforced by the fact that the flame of the briquette becomes more luminous during combustion in contrast to the flame without an adjuster (refer to Figures 5 and 6).

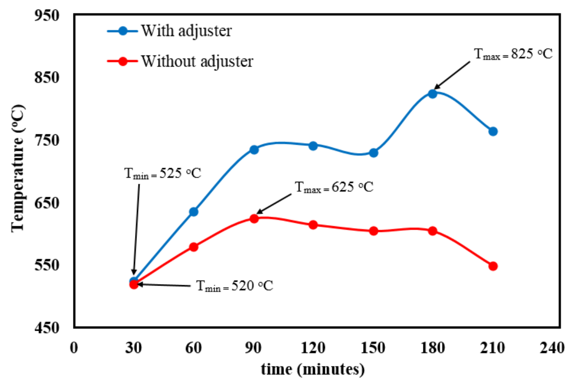

Figure 8. Temperature evolution of the pan (T_2).

Moreover, as the reactivity of molecules increase, thus viscosity decreases, allowing for easier heat absorption and combustion. Furthermore, this analysis concurs with previous studies from various perspectives [20] and it is substantiated by the increase in temperature observed during the burning stages (refer to Figure 7 and 8).

CONCLUSIONS

The investigations have successfully examined the impact of incorporating a modifier on the briquette of sago waste. Consequently, several key findings can be deduced from this study, which are as follows:

1. The utilization of an adjuster holds significant importance as it effectively maintains a consistent burning distance. Therefore, it is crucial to consider its implementation for ensuring flame stability and enhancing the efficiency and effectiveness of combustion heat.

2. The dense arrangement of carbon atoms in the briquette fuel's molecular structure acts as a highly efficient conductor, facilitating the swift transmission of heat throughout the flame. Therefore, the flame becomes steadier and emits a stronger light.
3. The density of fuel molecules promotes effective collisions when subjected to heat, leading to heightened reactivity of fuel molecules, improved heat absorption, and efficient combustion.

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