

Investigating the Role of Heating Height in Gas Stove Burner Performance

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Abstract. This study provides a detailed analysis of the effect of heating height on thermal efficiency and heat transfer characteristics in combustion systems. Numerical simulations were performed for pots with diameters of 160 mm, 180 mm, and 200 mm at heating heights of 2 to 6 mm. The results indicate that smaller pots achieve maximum thermal efficiency at lower heating heights, while larger pots require higher heating heights to optimize their performance. More specifically, the PD160, PD180, and PD200 pots achieve maximum efficiencies of 59%, 61%, and 64% at 2 mm, 4 mm, and 6 mm, respectively. Analysis of the temperature contour shows that lower heating heights allow the flame to interact with the bottom of the pot in its hottest area, generating a more pronounced temperature gradient and better heat transfer. These results highlight the essential role of aligning pot geometry with heating conditions to improve energy utilization and boiling performance, providing guidance for stove design and cookware optimization.

1 Introduction

Cooking energy systems rely on a wide range of fuel technologies, which can be broadly classified according to their combustion characteristics and environmental impact. Among these, liquefied petroleum gas (LPG) is one of the most widely used cooking fuels due to its high specific energy [1], clean combustion, and widespread availability [2].

In 2022, domestic consumption accounted for approximately 45% of total LPG usage, exceeding that of other sectors such as agriculture, transport, and industry [3]. In countries such as Tunisia, the consumption of LPG is projected to reach approximately 446 ktep in 2025 [4]. This demand significantly exceeds domestic production, which covers less than 50% of total LPG consumption [5], highlighting

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the country's reliance on imports to meet its energy needs. This dominant share highlights the central role of LPG in household energy demand and emphasizes the importance of improving the efficiency of domestic LPG-based systems.

Researchers have long been tackling the problem of how to boost their efficiency while lowering pollutant emissions in order to further enhance their performance. The heating height (the distance between the burner outlet and the bottom of the pot) is one of the numerous factors to take into account [6–8]. Heat transfer, flame shape, and even combustion quality, are all directly impacted by this small distance.

Teotia et al. [9] studied the effect of loading height on the thermal efficiency of domestic LPG burners by gradually varying it using metallic strips of 1.7 mm. The results showed that thermal efficiency is highest at an optimum height of 14.1 mm (cold phase) and 14.6 mm (hot phase), while any deviation reduces efficiency by up to 18.5%. Using adjustable or multiple-height stands is recommended to maintain optimum heating and improve fuel economy.

Islam et al. [10] examined the effect of loading height and found that the highest thermal efficiency (64.4%) was achieved with an ordinary flat-bottom pot equipped with a bottom shield at an optimum loading height of 3 cm and a natural gas pressure of 0.6 kPa.

2 System Description and Methodology

2.1. Geometric Parameters

Figure 1 presents the geometric configuration used for the numerical simulations, where the heating height is fixed at 10 mm and the vessel diameter is set to 180 mm[11]. In this work, the interaction between heating height and vessel diameter is analyzed to determine the optimal operating conditions of the gas stove burner.

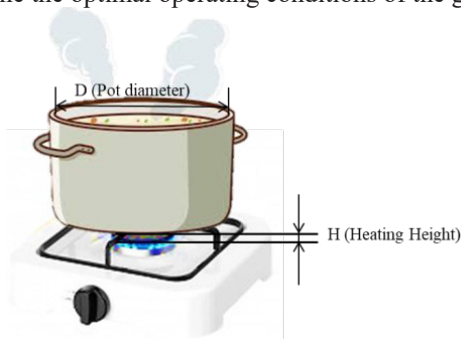


Fig. 1. Geometric configuration used in the numerical simulations (heating height = 10 mm, vessel diameter = 180 mm).

Table 1 summarizes the geometrical configurations of the different pot models considered in this study. The table lists the pot diameter (D), the diameter of the burner cap, the diameter of the holes, and the heating height (H). Three models are presented: PD160, PD180, and PD200, with pot diameters of 160 mm, 180 mm, and 200 mm, respectively. For all models, the burner cap diameter is 80 mm, the hole diameter is 2 mm, and the heating height varies from 0.5 mm to 14 mm.

Table 1. Design parameters of pots and burners used in the study.

Designation of the configuration model	Diameter of the pot (D)	Diameter of the cap burner	Diameter of the holes	Heating height (H)
PD160	160 mm	80 mm	2 mm	0,5 to 14 mm
PD180	180 mm	80 mm	2 mm	0,5 to 14 mm
PD200	200 mm	80 mm	2 mm	0,5 to 14 mm

2.2. Numerical Model and Boundary Conditions

Figure 2 presents the computational domain and mesh configuration used in the numerical simulations. The figure highlights the structured mesh applied to the vessel and burner regions to accurately capture the complex geometry and flow features. Key boundary conditions are indicated, including the fuel inlet, vessel wall, and periodic symmetry planes, which are employed to reduce computational cost while preserving flow symmetry. The geometric parameters defining the system, namely the heating height (H) and the vessel radius (R), are also illustrated. This meshing strategy ensures adequate resolution near the walls and in the flame region, enabling reliable prediction of flow, heat transfer, and combustion characteristics.

The boundary conditions applied in the numerical simulations are defined as follows. The fuel inlet is specified as a velocity inlet with a constant velocity of 0.5 m/s, determined from experimental measurements. The outlet is modeled as a pressure outlet with a gauge pressure of 0 Pa. The pot wall is imposed as a constant temperature boundary at 403 K [12], also obtained experimentally, while the burner wall is assumed to be adiabatic. The simulations are performed using a pressure-based solver under steady-state conditions. The turbulence effects are modeled using the realizable $k-\epsilon$ turbulence model, which is well-suited for capturing swirling and recirculating flows. Combustion is described by the eddy dissipation model, where the reaction rate is controlled by turbulent mixing. The chemical reaction mechanism is adopted from Das et al [12], ensuring consistency with validated combustion kinetics for similar configurations. In addition, radiation heat transfer is taken into account using the Discrete Ordinates (DO) radiation model, allowing accurate prediction of thermal radiation within the combustion chamber.

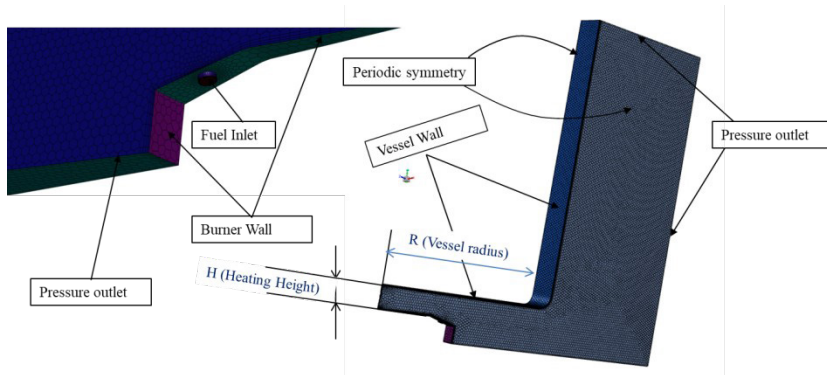


Fig. 2. Computational mesh and geometric parameters of the model.

2.3. Experimental Validation

Figure 3 shows the stable and symmetrical structure of a gas burner flame. The measurement points (P3', P2', P1', P0, P1, P2, and P3) indicate the locations of thermal pairs along the flame front, which are used to analyze the temperature value at these points.

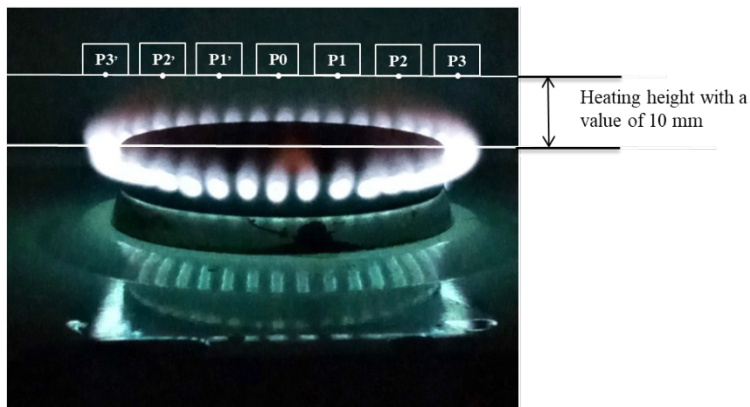


Fig. 3. Thermocouple measurement locations of the gas burner.

Figure 4 illustrates the temperature distribution at various radial and longitudinal positions (P3' to P3) for the experimental data and three different mesh configurations. Among the tested meshes, Mesh 3 shows the best agreement, with an error of only 6% compared to the experimental temperatures, followed by Mesh 2 and Mesh 1, indicating that Mesh 3 provides the most accurate representation of the thermal behavior.

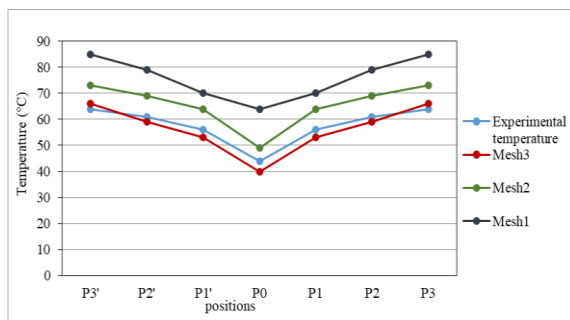


Fig. 4. Flame behavior and temperatures at the measuring plate for H = 10 mm.

3 Results and Discussion

3.1 Optimization of Heating Height for Different Pot Diameters

Figure 5 shows the effect of heating height on the boiling thermal efficiency for pot diameters. For all cases, the efficiency increases with heating height up to an optimum value, beyond which it decreases.

At low heating heights, the flame strikes the bottom of the pot directly, resulting in poor mixing and significant heat loss. Increasing the heating height stabilizes the flame and allows the hot gases to distribute evenly under the pot. This improves heat transfer and increases thermal efficiency [12]. When the heating height increases, the flame becomes more stable and the hot gases spread more evenly under the pot. This improves heat transfer and increases thermal efficiency. The largest pot diameter (PD200) gives the highest efficiency, about 64% at a heating height of 6 mm, because it offers a larger heat transfer area and uses the flame more effectively. However, increasing the heating height further reduces efficiency for all cases. The flame becomes too far from the pot, and more heat is lost to the surroundings. These results show that there is an optimal heating height, which depends on the pot diameter and balances flame stability and heat losses.

Similar results were reported by Teotia et al. [9] and Hou et al. [6]. They showed that thermal efficiency increases with heating height up to an optimum value and then decreases. In this study, the same trend is observed. In addition, the effect of pot diameter is included, and smaller changes in heating height are used to better understand its influence on efficiency.

By applying this formula, the simulation results can be directly compared with experimental measurements, allowing the performance of the stove to be evaluated and energy losses during cooking to be determined.

$$\eta_{th} = [(q * A_p) / Q_f] \tag{1}$$

Where:

η_{th} : Thermal efficiency.

q : Total wall heat flux [kW/m²].

A_p : Area of the inner pot wall surface [m²].

Q_f : Heat release from combustion reaction [kW].

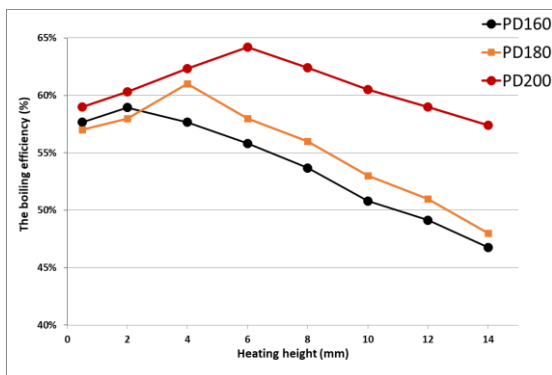


Fig. 5. Variation of thermal efficiency with heating height for vessel diameters of PD160, PD180, and PD200

3.2 . Temperature Contours

Figure 6 shows the temperature contours for the model with heating heights of 6, 10, and 14 mm. The maximum temperature at the fuel inlet is 2174 K. At a lower heating height, the flame touches the bottom of the pot with its hottest region, whereas increasing the heating height causes the flame to contact the surface with its tip, where the temperature is lower. This explains the decrease in thermal efficiency with

increasing heating height. At a heating height of 6 mm, the green zone shows a noticeable contrast with the side of the pot, compared to the models with heating heights of 10 mm and 14 mm. This difference in temperature distribution highlights the effect of heating height on the thermal profile of the pot surface. Specifically, the 6 mm heating height produces a more concentrated and pronounced temperature gradient near the pot wall, with the green zone indicating higher-temperature areas compared to the surrounding blue zone.

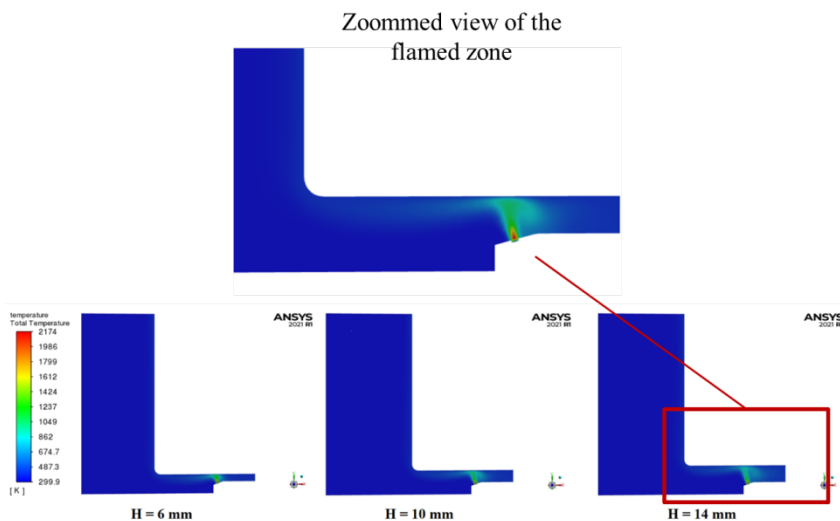


Fig. 6. Temperature contours of different heating heights: 4 mm, 6 mm and 14 mm.

4 Conclusion

This study investigated the influence of heating height on the performance of gas stove burners across different pot diameters. The results demonstrate a clear relationship between pot size and optimal heating height for maximizing thermal efficiency. Smaller pots (PD160) achieve peak efficiency at lower heating heights (2 mm), while larger pots (PD180 and PD200) require progressively higher heating heights (4 mm and 6 mm, respectively) to reach maximum efficiency. The findings highlight that proper matching of pot geometry with burner heating conditions is essential for achieving efficient energy utilization and improved boiling performance. These insights provide practical guidance for both stove design and cookware selection to enhance domestic energy efficiency. The optimal case is PD160 at a heating height of 6 mm, with a thermal efficiency of 64%.

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