

Development of Apparatus for Increasing Efficiency and Savings in Radiation and Convection Heat Transfer in Stovetops

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Abstract:

A new apparatus is designed to increase the efficiency and save fuel in electric and gas stoves used in kitchens. Through analyses and experiments, improvements are made to this apparatus to utilize a larger amount of heat lost through convection and radiation, thus saving electricity and gas fuel used in stoves. Initial and final heat values and cooking energies is compared. A test unit is prepared for this purpose, using an electric and gas stove, a pot with a diameter of approximately 17 cm, and a specific amount of water. Equipment used will include a thermometer, a stopwatch, and a thermal camera. Different diameter and thickness designs of the apparatus is created. These are incorporated heat insulation material to facilitate heat transfer to the outside environment: radiant heat transfer via a bright inner surface, conductive heat transfer via the insulation material, and convective heat transfer by lowering the outer surface temperature with the insulation material. The apparatus is designed with lower openings for air intake to improve gas combustion and upper openings for exhaust outlet. In the experiments, the time it takes for water in a steel pot to reach 80°C is determined for various designs of the appliance on a natural gas stovetop, and the efficiency increases and results are shown graphically. Lots of experiments done and the figures show for electric stove that uninsulated round without sheet metal plates the best performance with 9 minutes obtained for electric stove. For gas stove, with the device developed from 0.5 mm steel the temperature rises from 20°C to 80°C in 9 minutes, which is the best performance among all of the other alternatives.

1. Introduction

The aim of this study is to design a new apparatus to increase the efficiency of electric and gas stoves used in kitchens and to save fuel. This apparatus would reduce the amount of heat energy lost to the environment during heating and cooking in electric and gas stoves, thus saving natural gas or, in the case of electric heaters, electricity. The goal is to contribute to both the national and household economies by saving energy spent on heating and cooking in stoves, which constitute a significant part of household energy consumption. There are no existing studies on this subject in Turkish literature, and very few in foreign literature. While some studies investigating this neglected and important

issue in our daily lives have been published in prestigious journals, these studies are not holistic but rather fragmented. Here, an insulated apparatus is developed to reduce, recover, and save heating energy lost through radiation and convection in both gas and electric stoves, and the effects of different geometries are investigated. For this purpose, experiments are conducted on electric and gas stoves using an insulated ring design. To minimize the negative impact of insulated ring-shaped apparatus on combustion efficiency, emissions, and particulate matter formation for gas stoves, various geometries for combustion air inlet and exhaust outlet in the insulated ring are tested to find the optimum design. The combustion process, temperature distribution, and the effect of the insulated ring-shaped apparatus

on the thermal process are monitored using a thermal camera.

A new apparatus is designed to increase the efficiency and save fuel in gas and electric stoves used in kitchens. Through analysis and experiments, improvements are made to this apparatus to utilize a larger amount of heat lost through convection and radiation, thus saving electricity and gas fuel used in stoves. Initial and final heat values and cooking energies are compared. A test unit is prepared for this purpose, using a natural gas stovetop in a home, a pot with a diameter of approximately 17 cm, and equipment such as a thermometer, stopwatch, and thermal camera.

Different diameter and thickness designs of the apparatus are created. These will incorporate heat insulation material to facilitate heat transfer to the outside environment through a bright inner surface (radiation), conduction (by means of insulation), and convection (by reducing the outer surface temperature). The apparatus is designed with lower openings for air intake to improve gas combustion and upper openings for exhaust. In experiments, the time it takes for water in a steel pot to reach 80 °C and the amount of energy consumed is determined for various designs of the appliance on a natural gas stovetop. The efficiency improvements and results are also shown graphically.

Kang et al. (2023) developed an apparatus using an insulating material to increase the efficiency of electric radiant heaters used in cooking and experimentally and theoretically demonstrated that 10% of the heat energy transferred to the pot during cooking could be saved [1]. The insulated ring-shaped apparatus they developed reduced losses through convection and radiation. However, in their study, they did not examine the effect of insulation thickness and type of insulation, and only studied electric heaters, neglecting gas stoves. Cernela et al. (2014) investigated the effect of pan thickness on efficiency in cooking and frying and found that thinner pans are more efficient than thicker pans, considering heat energy transferred by radiation, convection, and conduction for both electric and gas ovens [2]. Joshi et al. (2022) investigated the effect of the geometry of cooking pots on energy efficiency and tried to find the optimum geometry for pots as a result of their experimental and theoretical studies [3]. Sanz-Serrano et al. (2016) attempted to determine the energy and temperature distribution of electric and gas cooktops using reverse modelling to optimize their design [4]. Wang et al. (2022) conducted experimental and theoretical studies to increase heat transfer and thermal efficiency by attaching fins to pots used in gas cooktops. They investigated the effect of the number of fins and their angle with the pot on thermal efficiency and found

that efficiency could be increased by approximately 7% in this way [5]. Cadavid et al. (2014) investigated the thermal efficiency of pots used in electric cooktops and showed, using theoretical and experimental methods, that a significant portion of heat energy lost through radiation and convection could be prevented and thermal efficiency could be increased by approximately 18% by ensuring the electric cooktop is properly insulated and designed, and by selecting a pot with a wide base [6].

2. Material and Methods

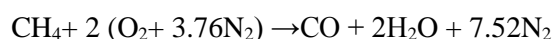
In this project an insulated apparatus is developed for reducing, recovering, and saving heating energy lost through radiation and convection in both gas and electric stoves, and the effects of different geometries are investigated. For this purpose, an insulated ring is designed and experiments are conducted on both electric and gas stoves. To minimize the negative impact of the insulated ring apparatus on combustion efficiency, emissions, and particle formation in gas stoves, various geometries for combustion air inlet and exhaust outlet are tested to find the optimum design. A test unit is prepared, using a household gas stovetop, a pot with a diameter of approximately 17 cm, and 1 liter of water. Equipment used are including a thermometer, a stopwatch, and a thermal camera.

The natural gas components announced by BOTAŞ are given below. Experiments and numerical analyses were carried out using natural gas distributed according to these specifications.

Table 1. Properties of natural gas [7]

Component	Mole Fraction	% Distribution
Methane	% 85	% 81.25
Ethane	% 9	% 8.60
Propane	% 1.8	% 1.72
Butane	% 1.7	% 1.63
Pentane	% 0.8	% 0.76
Hydrogen	% 0	% 0
Sulfur	% 0	% 0
Oxygen	% 0.42	% 0.40
Carbon dioxide	% 1.5	% 1.43
Nitrogen	% 4.38	% 4.21
TOTAL	104.60	100

Combustion equation for methane,



Energy conservation law

$$\Delta \dot{E}n = \dot{Q} - \dot{W} \quad (1)$$

$\Delta \dot{E}n$ is the change in energy (kW), \dot{Q} is heat (kW) and \dot{W} is work (kW) [8, 9, 10]. For internal energy can be written that

$$\Delta \dot{U} = \dot{Q} - \dot{W} \quad (2)$$

$$du = c_v dT \quad (3)$$

$$\Delta U = mc_v(T - T_0) \quad (4)$$

ΔU is change in internal energy (kW) [11, 12]. For heat transfer analysis conduction law is

$$q_x = -k \frac{dT}{dx} \quad (5)$$

k is conduction constant (W/mK) and q is heat (W). The convection law is

$$Q = h \cdot A \cdot (T_y - T_a) \quad (6)$$

A is the area (m^2) and h is convection constant (W/m^2K). The radiation law is

$$En = \epsilon \sigma T^4 \quad (7)$$

ϵ emissivity and σ is Stefan-Boltzmann constant ($5.67 \times 10^{-8} W/m^2K^4$) [13, 14, 15]. Total net heat radiation from area A is

$$\dot{Q} = \frac{\dot{E}_s - j}{\frac{1-\epsilon}{\epsilon A}} \quad (8)$$

Different diameter and thickness apparatus designs are created for testing. Heat transfer to the external environment is facilitated by radiant heat transfer through the bright inner surface, conduction through the insulation material, and convection through lowering the outer surface temperature using the insulation material. The apparatus is designed with lower openings for air intake and upper openings for exhaust to improve gas combustion. Experiments are determined how long it takes for 1 liter of water in a steel pot to reach 80 °C on a natural gas stovetop, using various designs of the apparatus. The efficiency improvements and results are shown graphically. Methods are developed to achieve optimum geometries, insulation thicknesses, and minimum consumption.

In our experiments bright (mirror-reflective) stainless steel sheets, 0.5, 1 and 1.5 mm thick, measuring 25x80 cm are used.

In Figure 1 the photograph of an experiment showing temperature and time variations conducted

by covering a steel pot with a circular sheet metal plate is given.

In Figure 2 the original image of a gas stove sold on the market is given.



Figure 1. Photograph of an experiment showing temperature and time variations conducted by covering a steel pot with a circular sheet metal plate.



Figure 2. The original image of a gas stove sold on the market.

In figure 3 the image shows a commercially available, original gas stove with the lid attachment removed.



Figure 3. The image shows a commercially available, original gas stove with the lid attachment removed.

3. Results and Discussions

3.1. Electric Stoves Used in Kitchens

In this section the experiments have done with electric stove used in kitchen is explained. In Figure 4 the image of a steel pot being insulated with sheet metal without using circular plates is given.



Figure 4. The image of a steel pot being insulated with sheet metal without using circular plates.

In Figure 5, the thermal camera image of the heat loss from the pot to the surroundings before the sixth minute is given. The figures 5 and 6 show the heat loss from the pot and the appliance casing to the

surroundings after the sixth minute. The appliance casing is not insulated and is coated with enamel on the steel sheet. As can be seen that most of the heat loss was happened on the steel casing. In fact, the steel casing of the appliance should be properly insulated from the bottom and top. In Figure 6, the thermal camera image of the insulation around the steel pot and its interior and exterior covered with circular sheet metal is given. As seen in the thermal camera images in Figures 5 and 6, before and after the sixth minute, a significant amount of heat is lost from the pot and the appliance's casing to the surroundings, and the temperature of the steel sheet rises far above the temperature of the pot and the water.

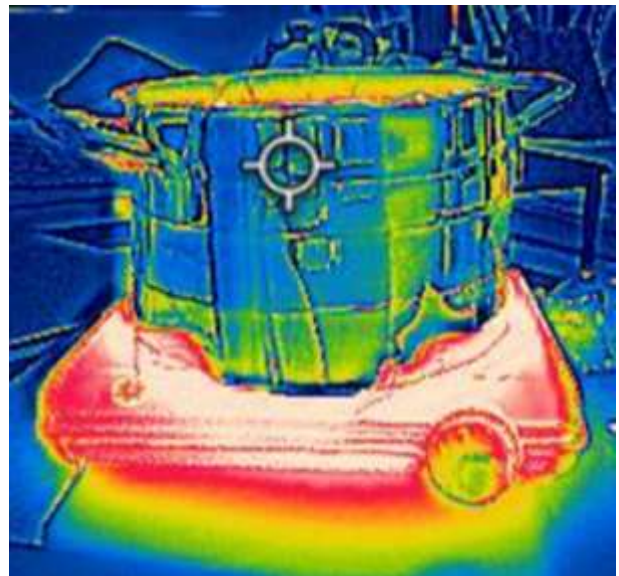


Figure 5. Thermal camera image of heat loss from the pot to the surroundings before the sixth minute.

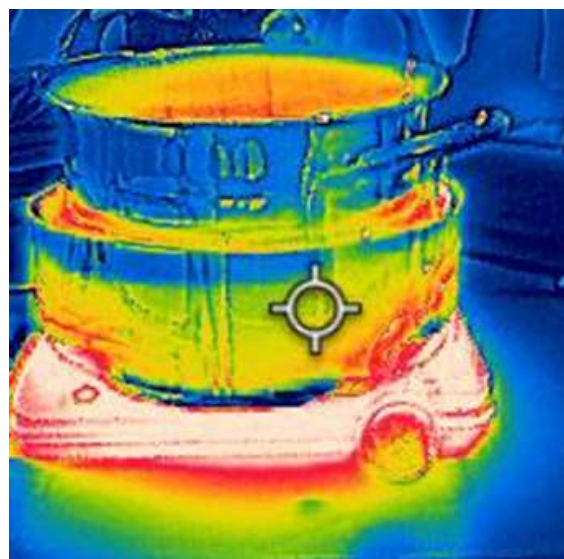


Figure 6. Thermal camera image of the insulation around a steel pot and its interior and exterior covered with circular sheet metal.

Figures 7 show the temperature and time variation when insulating a steel pot with 5 mm, 10 mm, and 15 mm thicknesses without using round sheet metal. As seen in the figure, the temperature rises from 20°C to 80°C in 9 minutes for 5 mm sheet, 10 minutes for 10 mm sheet, and 11 minutes for 15 mm sheet. The performance is best with 5 mm sheet which is 10% better than the other two.

Figures 8 show the temperature and time variations when steel pots are insulated with 5 mm, 10 mm, and 15 mm thicknesses, and the inside is covered with a 0.5 mm thick round sheet metal plate. As seen in the figure, the temperature rises from 20°C to 80°C in 11.8 minutes with 0.5 mm steel sheet metal and 5 mm insulation, in 11.6 minutes with 0.5 mm steel sheet metal and 10 mm insulation, and in 11.4 minutes with 0.5 mm steel sheet metal and 15 mm insulation. The performance is best with 0.5 mm steel sheet metal and 15 mm insulation and better the other two about 2-3%.

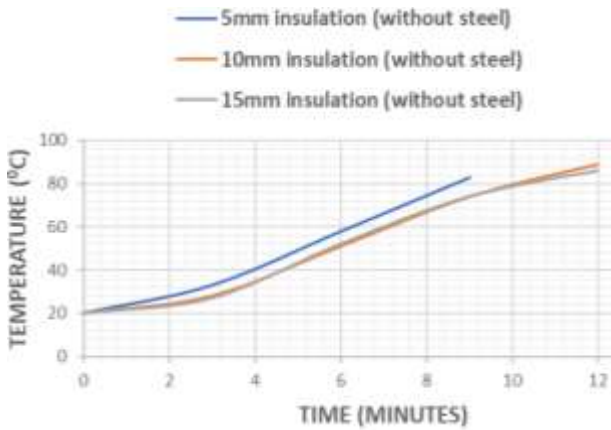


Figure 7. Temperature and time variation when insulating a steel pot with 5 mm, 10 mm, and 15 mm thicknesses without using round sheet metal.

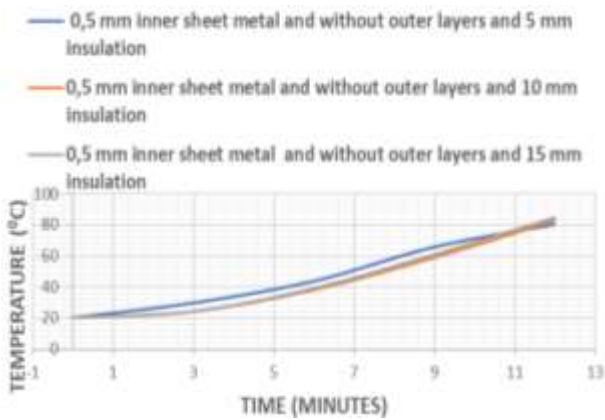


Figure 8. Temperature and time variations when steel pots are insulated with 5 mm, 10 mm, and 15 mm thicknesses, and the inside is covered with a 0.5 mm thick round sheet metal plate.

Figures 9, show the temperature and time variations when steel pots are insulated with 5 mm, 10 mm, and 15 mm thicknesses, and the inside and outside are covered with 0.5 mm thick round sheet metal. As seen in the figures, the temperature rises from 20°C to 80°C in 23 minutes with 5 mm insulation, 21 minutes with 10 mm insulation, and 25 minutes with 15 mm insulation. The performance is best with 0.5 mm the inner-outer side thick steel sheet on of the insulation 10 mm insulation and better about 9-16%.

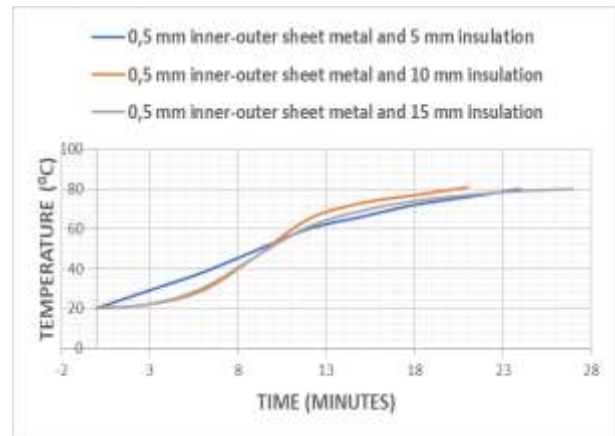


Figure 9. Temperature and time variations when steel pots are insulated with 5 mm, 10 mm, and 15 mm thicknesses, and the inside and outside are covered with 0.5 mm thick round sheet metal.

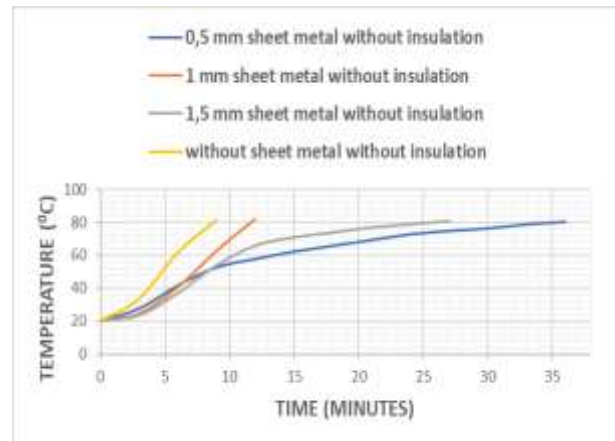


Figure 10. Temperature and cooking time variation when a steel pot is not sealed and is instead covered with uninsulated round sheet metal plates of 0.5 mm, 1 mm, and 1.5 mm thickness.

In Figure 10, the temperature and cooking time variation when a steel pot is not sealed and is instead covered with uninsulated round sheet metal plates of 0.5 mm, 1 mm, and 1.5 mm thickness are given. As seen in the figures, the temperature rises from 20°C to 80°C in 9 minutes with not sealed, 34 minutes with 0.5 mm sheet metal plates insulation, 12 minutes with 10 mm sheet metal plates insulation, and 27 minutes with 15 mm sheet metal plates

insulation. The performance is best in 9 minutes with not sealed one and better than the other three about 25-65%.

As can be seen from the figures and lots of experiments uninsulated round without sheet metal plates the best performance with 9 minutes obtained. As seen in the thermal camera images in Figures 5 and 6, before and after the sixth minute, a significant amount of heat is lost from the appliance's casing to the surroundings, and the temperature of the steel sheet of the electric stove rises far above the temperature of the pot and the water at least about 50%. Electric stoves used in kitchen should be properly insulated from the bottom and top.

3.2. Gas Stoves Used in Kitchens

In this section the experiments have done with gas stove used in kitchen is explained.

In Figure 11, a photo showing a steel pot being heated with the lid closed.



Figure 12. The image shows a gas stove with its heating elements removed, without any support or balance.

In Figure 11, the image shows a gas stove with its heating elements removed, without any support or balance.

In Figure 12 a photo showing a steel pot being heated with the lid closed.

In Figure 13, the temperature and time variation for a steel pot bottom with a 1.5 cm exhaust outlet, 0.5 mm thick sheet metal, 13 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm are given. As seen in the figures, the temperature rises from 20°C to 80°C in 18 minutes with air inlets of 0.8 cm, 21 minutes with air inlets of 1.6 cm, and 24 minutes with air inlets of 2.4 cm. The performance is best in 0.5 mm thick sheet metal, 13 cm diameter with air inlets of 0.8 cm and better about 15-25% than the other two.



Figure 12. A photo showing a steel pot being heated with the lid closed.

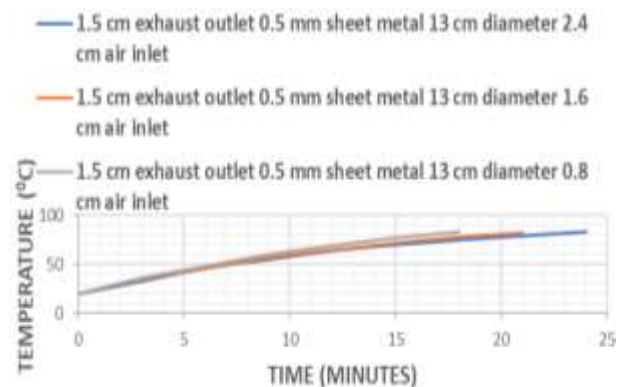


Figure 13. Temperature and time variation for a steel pot bottom with a 1.5 cm exhaust outlet, 0.5 mm thick sheet metal, 13 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm.

In Figure 14, the temperature and time variation for a steel pot bottom with a 1.5 cm exhaust outlet, 1 mm thick sheet metal, 14 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm are given. As seen in the figures, the temperature rises from 20°C to 80°C in 18 minutes with air inlets of 0.8 cm, 21 minutes with air inlets of 1.6 cm, and 24 minutes with air inlets of 2.4 cm for 14 cm diameter. The performance is best in 0.5 mm thick sheet metal, 14 cm diameter with air inlets of 0.8 cm and better about 15-25% than the other two.

In Figure 15, the temperature and time variation for a steel pot bottom with a 1.5 cm exhaust outlet, 0.1 mm thick sheet metal, 15 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm are given. As seen in the figures, the temperature rises from 20°C to 80°C

in 18 minutes with air inlets of 0.8 cm, 21 minutes with air inlets of 1.6 cm, and 24 minutes with air inlets of 2.4 cm for 15 cm diameter. The performance is best in 0.5 mm thick sheet metal, 15 cm diameter with air inlets of 0.8 cm and better about 15-25% than the other two.

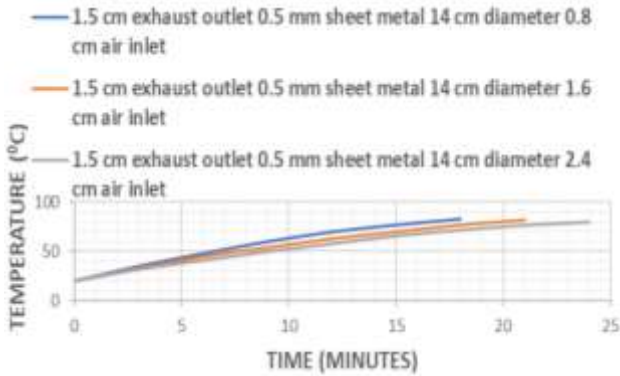


Figure 14. Temperature and time variation for a steel pot bottom with a 1.5 cm exhaust outlet, 1 mm thick sheet metal, 14 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm.

Figure 13, 14 and 15 show that the diameter of the sheet metal has no effect on the performance and the efficiency. However, the air inlet height is effective on the performance and the efficiency and the best height is found as 0.8 cm.

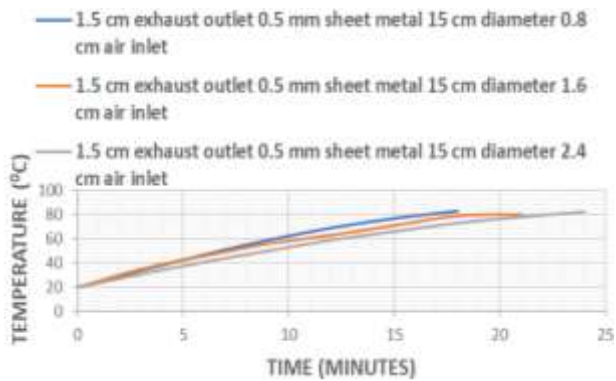


Figure 15. Temperature and time variation for a steel pot bottom with a 1.5 cm exhaust outlet, 0.5 mm thick sheet metal, 15 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm.

In Figure 16, the temperature and time variation with a 1.5 cm exhaust outlet on the bottom of a steel pot, a 1 mm thick sheet metal, a 13 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm. are given. As seen in the figures, the temperature rises from 20°C to 80°C in 18 minutes with air inlets of 0.8 cm, 21 minutes with air inlets of 1.6 cm, and 23 minutes with air inlets of 2.4 cm for 13 cm diameter. The performance is best in with air inlets of 0.8 cm and better about 14-20% than the other two.

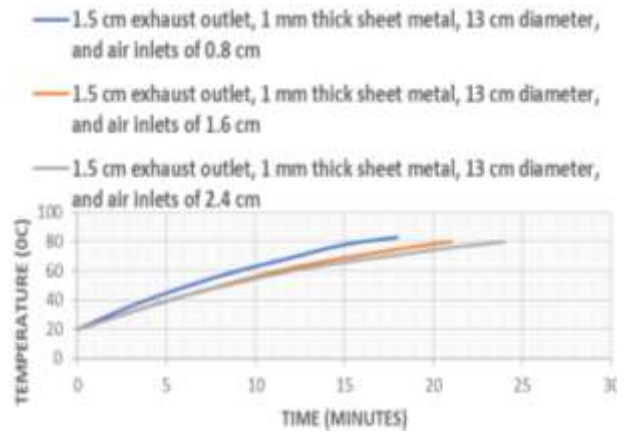


Figure 16. Temperature and time variation with a 1.5 cm exhaust outlet on the bottom of a steel pot, a 1 mm thick sheet metal, a 13 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm.

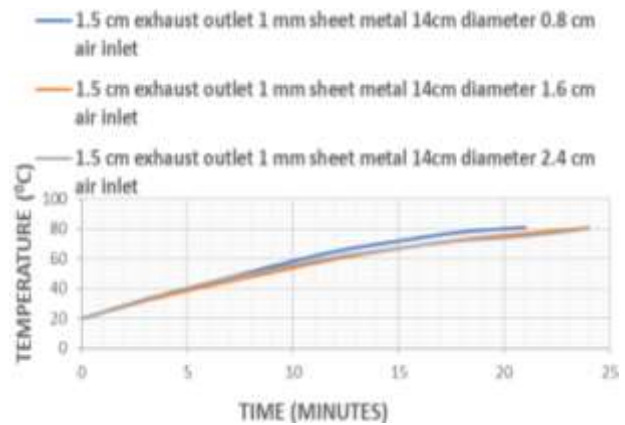


Figure 17. Temperature and time variation for a steel pot bottom with a 1.5 cm exhaust outlet, 1 mm thick sheet metal, 14 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm.

In Figure 17, the temperature and time variation with a 1.5 cm exhaust outlet on the bottom of a steel pot, a 1 mm thick sheet metal, a 14 cm diameter, and air inlets of 0.8 cm, 1.6 cm, and 2.4 cm. are given. As seen in the figures, the temperature rises from 20°C to 80°C in 21 minutes with air inlets of 0.8 cm, 22 minutes with air inlets of 1.6 cm, and 23 minutes with air inlets of 2.4 cm for 13 cm diameter. The performance is best in with air inlets of 0.8 cm and better about 5-10% than the other two.

In Figure 18, the temperature and time variation with steel pot bottom with 1.5 cm exhaust outlet, 1 mm thick sheet metal, 15 cm diameter, 0.8 cm, 1.6 cm and 2.4 cm air inlet, are given. As seen in the figures, the temperature rises from 20°C to 80°C in 21 minutes with air inlets of 0.8 cm, 22 minutes with air inlets of 1.6 cm, and 23 minutes with air inlets of 2.4 cm for 15 cm diameter. The performance is best in with air inlets of 0.8 cm and better about 4-9% than the other two.

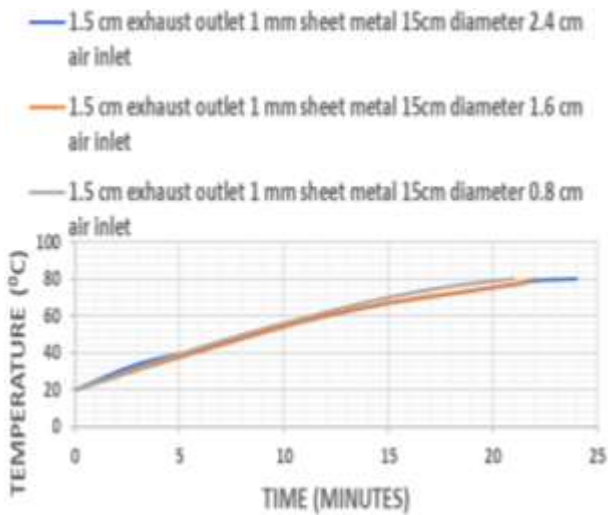


Figure 18. Steel pot bottom with 1.5 cm exhaust outlet, 1 mm thick sheet metal, 15 cm diameter, 0.8 cm, 1.6 cm and 2.4 cm air inlet, temperature and time variation depending on the situation.

Figure 16, 17 and 18 show that the diameter of the sheet metal has no effect on the performance and the efficiency, increasing the thickness of the sheet metal decreases the performance. However, the air inlet height is effective on the performance and the efficiency and the best height is found as 0.8 cm. In Figure 19, the thermal camera image of the bottom side of the steel pot are given. In Figure 20, the image of newly developed attachments for a gas stove are given.

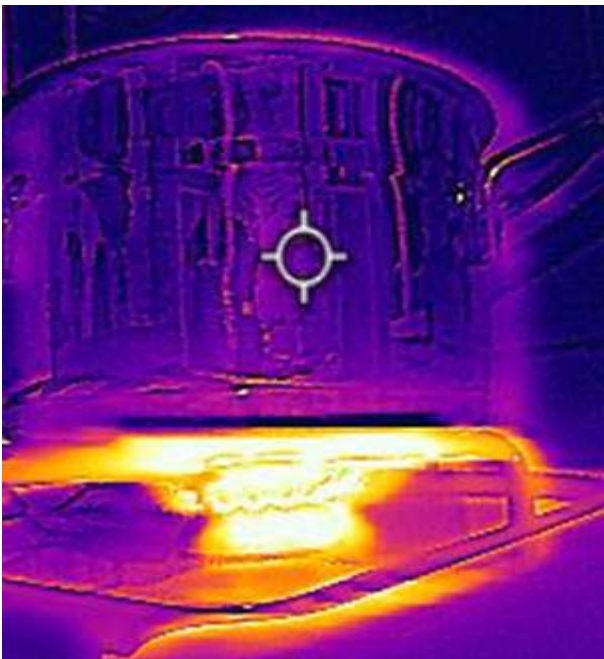


Figure 19. Thermal camera image of the bottom side of the steel pot.

In Figure 21, the heating image of newly developed gas stove attachments with the steel pot are given.



Figure 20. Image of newly developed attachments for a gas stove.



Figure 21. Heating image of newly developed gas stove attachments.

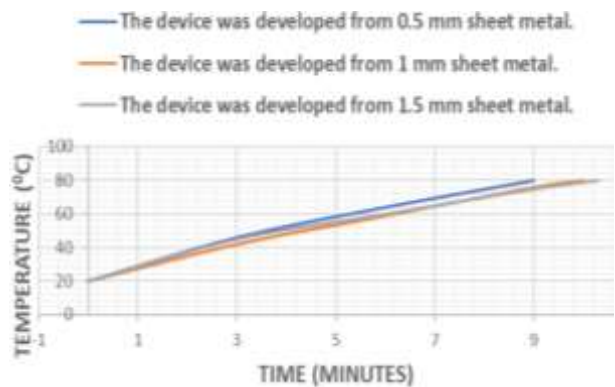


Figure 22. Temperature and time variations of attachments developed from 0.5 mm, 1 mm, and 1.5 mm steel sheets to raise the temperature of a steel pot from 20°C to 80°C in the shortest possible time on a gas stove.

In Figure 22, the temperature and time variations of attachments developed from 0.5 mm, 1 mm, and 1.5 mm steel sheets to raise the temperature of a steel pot from 20°C to 80°C in the shortest possible time on a gas stove are given. As seen in the figures, the temperature rises from 20°C to 80°C in 9 minutes

with the device developed from 0.5 mm steel, 10 minutes with the device developed from 1 mm steel, 10.4 minutes with the device developed from 1.5 mm steel. The performance is best with the device developed from 0.5 mm steel and better about 10-15% than the other two.

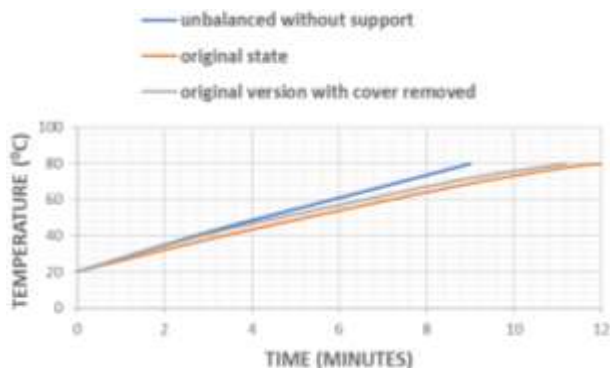


Figure 23. Temperature and time variations to raise the temperature of a steel pot from 20°C to 80°C on an original gas stove, without lid or support, while it is in its bare state.

In Figure 23, the temperature and time variations to raise the temperature of a steel pot from 20°C to 80°C on an original gas stove, without lid or support, while it is in its bare state. As seen in the figures, the temperature rises from 20°C to 80°C in 12 minutes on the original gas stove, in 11 minutes without a lid, and in 9 minutes without support. It performs best when left unsupported.

Figure 13, 14 and 15 are giving the same results that the diameters of the sheet metal are not effective on the performance. However, the air inlet height is effective on the performance and the efficiency and the best height is found as 0.8 cm and the best thickness of the sheet metal is 0.5 cm.

Figure 16, 17 and 18 show that the diameter of the sheet metal has no effect on the performance and the efficiency, increasing the thickness of the sheet metal decreases the performance. However, the air inlet height is effective on the performance and the efficiency and the best height is found as 0.8 cm and the best thickness of the sheet metal is found as 0.5 cm.

Figure 22 and 23, show that using unnecessary materials in heating and stoves decreases the performance and the efficiency. The important part of the energy spends for heating the pot and water are spend for increasing the temperatures and internal energy of the unnecessary materials and parts of stoves. For long time heating insulation might be useful, but the average cooking mass in a kitchen is about 1 or 3 kg food and so that insulation is wasting energy. On the original gas stove sold on the market as seen in the figures, the temperature rises from 20°C to 80°C in 12 minutes on the original

gas stove, in 11 minutes without a lid, and in 9 minutes without support. With the device developed from 0.5 mm steel the temperature rises from 20°C to 80°C in 9 minutes, which is the best performance among all of the other alternatives.

4. Conclusions

Lots of experiments done and the figures show for electric stove that uninsulated round without sheet metal plates the best performance with 9 minutes obtained. As seen in the thermal camera images in before and after the sixth minute, a significant amount of heat is lost from the appliance's casing to the surroundings. The temperature of the steel sheet of the electric stove rises far above the temperature of the pot and the waste energy is at least about 50%. Electric stoves used in kitchen should be properly insulated from the bottom and top, to stop wasting energy.

Lots of experiments done is show that the diameters of the sheet metal are not effective on the performance of gas stoves. However, the air inlet height is effective on the performance and the efficiency, and the best the air inlet height is found as 0.8 cm and the best thickness of the sheet metal is 0.5 cm. It is seen that increasing the thickness of the sheet metal decreases the performance of gas stoves. Lots of experiments done are showed that using unnecessary materials in heating and stoves decreases the performance and the efficiency. Important part of the energy spends for heating the pot and water are spend for increases the temperatures and internal energy of the unnecessary materials and parts of gas stoves. For long time heating insulation might be useful, but the average cooking mass in a kitchen is about 1 or 3 kg food so that insulation is wasting energy. On the original gas stove sold on the market as seen in the figures, the temperature rises from 20°C to 80°C in 12 minutes on the original gas stove, in 11 minutes without a lid, and in 9 minutes without support.

With the device developed from 0.5 mm steel the temperature rises from 20°C to 80°C in 9 minutes, which is the best performance among all of the other alternatives. With the device developed from 0.5 mm steel 33% of the energy spend can be saving. By placing a magnet on the bottom of the developed device, it can be easily moved and prevented from tipping over. This allows for use with large pots and pans, and the distances can be adjusted according to the situation.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.

- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.
- **Use of AI Tools:** The author(s) declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

References

- [1] Yun Ji Kang, Sudhanshu Pandey, Su Il Park, Young Soo Kim, Jea Hyuk Wie, Doo Hyun Kim, Man Yeong Ha. Comprehensive analysis and design optimization of temperature distribution in radiant heaters for cooking applications. *Case Studies in Thermal Engineering* 52 (2023) 103687. <https://doi.org/10.1016/j.csite.2023.103687>
- [2] Jérémie Cernela, Bertrand Heyd, Bertrand Broyart. Evaluation of heating performances and associated variability of domestic cooking appliances (oven-baking and pan-frying). *Applied Thermal Engineering* 62 (2014) 758-765. <http://dx.doi.org/10.1016/j.applthermaleng.2013.08.045>
- [3] Saurabh P. Joshi, Dr. Dnyaneshwar R. Waghole. Experimental investigation on energy efficient design for household cooking utensils. *Materials Today: Proceedings* 63 (2022) 197-201. <https://doi.org/10.1016/j.matpr.2022.02.468>
- [4] F. Sanz-Serrano, C. Sagues, S. Llorente. Inverse modeling of pan heating in domestic cookers. *Applied Thermal Engineering* 92 (2016) 137-148. <http://dx.doi.org/10.1016/j.applthermaleng.2015.09.084>
- [5] Jianyou Wang, Wei Zhang, Tao Yang, Yunzu Yu, Chuang Liu, Bin Li. Numerical and experimental investigation on heat transfer enhancement by adding fins on the pot in a domestic gas stove. *Energy* 239 (2022) 122439. <https://doi.org/10.1016/j.energy.2021.122439>
- [6] Francisco J. Cadavid, Yonatan Cadavid, Andres A. Amell, Andres E. Arrieta, Juan D. Echavarría. Numerical and experimental methodology to measure the thermal efficiency of pots on electrical stoves. *Energy* 73 (2014) 258-263. <http://dx.doi.org/10.1016/j.energy.2014.06.017>
- [7] <https://www.botas.gov.tr/>
- [8] Rabi Karaali, İlhan Tekin Öztürk. Performance Analyses of Gas Turbine Cogeneration Plants. *J. of Thermal Science and Technology*, 37, 1, 25-33, 2017.
- [9] Karaali, R., Öztürk, İ. T. Effects of Ambient Conditions on Performance of Gas Turbine Cogeneration Cycles. *Journal of Thermal Science & Technology*, 37(1), 93-102, (2017).
- [10] Atasbak, M., Keven, A., Karaali, R. (2022). Exergy analyses of two and three stage cryogenic cycles. *Applied Rheology*, 32(1), 190-204. <https://doi.org/10.1515/arh-2022-0134>
- [11] Rabi Karaali, İlhan Tekin Öztürk. Efficiency Improvement of Gas Turbine Cogeneration Systems. *Tehnički vjesnik* 24, Suppl. 1(2017), 21-27. DOI:10.17559/TV-20140509154652
- [12] Karaali, R. (2023). Performance analyses of combined cycle power plants. *International Journal of Computational and Experimental Science and Engineering*, 9(2), 165-169. <https://doi.org/10.22399/ijcesen.1310338>
- [12] Oztekin, E. K., Gur, M. M., & Karaali, R. (2025). Thermoeconomic Analyses of Heat Pumps. *International Journal of Computational and Experimental Science and Engineering*, 11(1). <https://doi.org/10.22399/ijcesen.867>
- [13] Cakmak, B., & KARAALI, R. (2024). Exergetic Analyses of Detonation Engine Cogeneration Plants. *International Journal of Computational and Experimental Science and Engineering*, 10(1). <https://doi.org/10.22399/ijcesen.234>
- [14] Karaali, R. (2022). Investigation of inlet air pressure and evaporative cooling of four different cogeneration cycles. *Open Chemistry*, 20(1), 1632-1642. <https://doi.org/10.1515/chem-2022-0263>
- [15] Karaali, R. & Keven, A. (2022). Evaluation of four different cogeneration cycles by using some criteria. *Applied Rheology*, 32(1), 122-137. <https://doi.org/10.1515/arh-2022-0128>