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Experimental Investigation of the Effect of Cavity Joining Technique of Gas Ovens on Energy Consumption and the Environment

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This article aims to show the effect of the joining technique of the sheet metal parts of a cavity on energy consumption, energy efficiency class, and environmental impact in domestic gas ovens. An oven cavity can be joined by screwing or welding the metal parts. Experiments were carried out on two identical prototypes, which only differed in the joining method used to assemble the cavity. The energy consumption of the oven with the welded cavity is found to be 12.00–14.22% less than that of the oven with the screwed cavity. The energy efficiency classes of the two ovens were determined. According to the energy efficiency index (EEI) averages of the prototypes, the oven with a screwed cavity (EEI = 112.92) is in class B, and the oven with a welded cavity (EEI = 98.38) is in class A. In order to show the environmental impact of the appliances, the carbon footprint of the ovens for nonintense and intense use over a period of 1 year and 10 years was determined. It was found that the carbon footprint from ovens with screwed cavities is 12.92% higher than that of ovens with welded cavities due to excess fuel consumption.
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Keywords: gas ovens, energy consumption, energy efficiency, carbon footprint

1 Introduction

Household appliances contribute to nearly 25% of a building's environmental impact [1], with electric ovens ranking poorly in energy efficiency at only 10–12% [2,3]. The high cost and insufficient electricity production in various parts of the world have led to an increased demand for gas appliances, especially those that run on natural gas and propane (liquified petroleum gas (LPG)). One of the reasons why gas ovens are preferred is because they provide heat with more moisture than electric ovens, and as a result, the food itself is more moist. Oven preheating time, baking uniformity, and baking time are also some of the criteria in the oven design process [4].

However, in the European Union, electric ovens dominate built-in oven sales at 96%, leaving gas ovens with a smaller market share [5]. On the other hand, in Italy, approximately 62% of households have an electric oven, while around 20% own a gas oven due to culinary traditions [6]. Because of their significant market share, electric ovens have been the focus of many studies in contemporary literature [3,7–9].

A limited number of studies are available on domestic gas ovens. Some of them are investigations on gas cookstove burners [10–12], and most of them include computational fluid dynamics (CFD) analysis and a comparison between electric and gas ovens. Özdemir developed simulation models of turbulent combustion to produce prototypes with a design closer to the final product [13]. Mistry et al. proposed a CFD-based methodology to evaluate the performance of a gas oven [4]. Carson et al. presented four methods to measure heat transfer coefficients in a domestic fan oven [14]. Park et al. investigated the effect of different hole placements on the thermal performance in the fan case of a gas oven numerically [15].

Landi et al., emphasizing the importance of energy efficiency of household appliances, analyzed energy consumption and baking quality of the ovens and proposed a methodology for eco-design of domestic ovens [16]. Considering the environmental aspects of the ovens, Landi et al. presented a life cycle assessment of both electric and gas ovens [6]. There are studies on burners of gas ovens [17–20].

The construction of the cavity is an effective element for the energy efficiency of a gas oven. The technique used to join a cavity, whether by screwing or welding, is one of the crucial factors in achieving low energy consumption goals. Thermal expansion and contraction during heating and cooling cause heat to leak from the oven joints. In this study, the effect of the cavity joining technique on energy consumption, energy efficiency class, and environmental impact in gas ovens is investigated.

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2 Materials and Methods

The cavity parts of a gas oven can be joined by various techniques. The most used techniques are screw-type joining and welding. Joining the cavity with screws is easier and more cost-effective than welding. Due to the high temperature in ovens, contraction and expansion may occur. On the other hand, welding provides a more reliable and robust structure for connecting the cavity. The quality of this connection affects heat leaks and, therefore, directly impacts energy consumption.

This article presents a comparative experimental study between two gas ovens that have the same features, differing only by the joining technique of the cavities, which are welding and screwing. The energy consumption and energy class of the ovens were determined. Carbon emission factors vary according to the country due to how energy sources are provided. A country from each continent was chosen to present a wide range of projections. Carbon emission during the use phase of the ovens was obtained for the following countries: the United States, Canada, Turkey, Australia, the United Kingdom, and Pakistan. The environmental effect of the appliances was evaluated over 10 years of their lifetime. Both non-intensive and intensive use for oven frequency have been taken into consideration, which are 110 cycles per year [21] and 260 cycles per year, respectively [6].

3 Experimental Setup

Experiments were carried out on two identical prototypes, which differed only by the joining method—the cavity of one of the ovens was joined by screwing, while the other was joined by welding. The oven features are presented in Table 1. Energy consumption tests were conducted according to the European energy consumption measurement standard for gas-fired ovens (EN 15181:2017 + A1:2020).

The schematic of the experimental setup is shown in Fig. 1. The equipment was installed in a psychometric chamber to maintain the constant ambient temperature of 23 ± 2 °C during the tests. The room temperature is measured with a thermocouple at the same height as the center of the oven cavity and 0.5 m diagonally from one of the front edges of the appliance.

Gas flow is controlled by a built-in thermostatic gas tap inside the oven. The flowrate is constant for each oven set temperature, which are 140 K, 180 K, and 220 K. The load for the energy consumption test is a water saturated brick prepared according to the standard [22]. It is placed in the center of the oven with two thermocouples to measure the temperature inside the brick as defined in the standard. The position of the thermocouples is shown in Fig. 2.

Table 1 Characteristics of the ovens

Feature	Screwed/welded oven
Type	Freestanding cooker
Burner power	4.2 kW
Volume	135.9 l
Fuel	Natural gas (100% methane)
Heating element	Gas burner

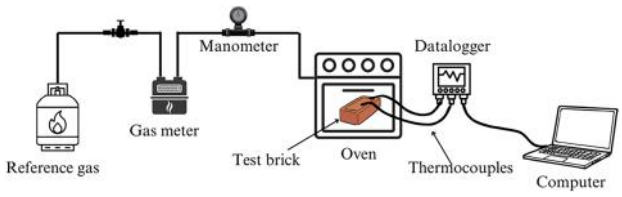


Fig. 1 Experimental setup

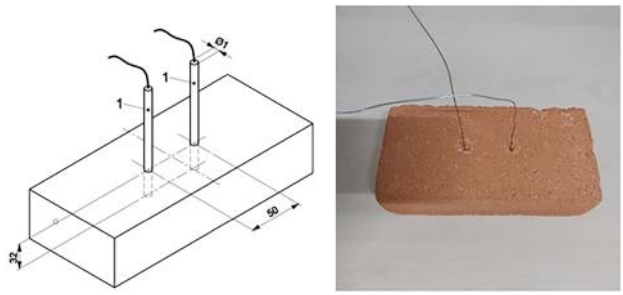


Fig. 2 Thermocouple placement in brick

Table 2 Oven settings

	Heating functions	
Oven temperature rise	Conventional	Forced air
ΔT_1	(140 −0/+10) K	(150 ± 5) K
ΔT_2	(180 ± 5) K	(165 ± 5) K
ΔT_3	(220 ± 5) K	(180 ± 5) K

The brick is weighed before and after the test to determine the water loss during the test cycle.

The oven temperature is set to a value that the difference between the average ambient temperature and the oven temperature (ΔT_k) will be as defined in Table 2, where $k = 1,2,3$. The brick is removed from the oven when its center temperature has reached 55 K rise from the starting temperature. The oven is run with the same settings after brick removal to measure the oven temperature at steady-state conditions, and three thermocouples are used to measure the temperature.

While the brick that simulated the food was heated, the center temperature was measured with two thermocouples. The thermocouples used for measurements are type K with ±1.1 °C accuracy. Temperature data were taken by a data logger with six reading channels and 0.006% accuracy. The measurement range of the manometer is 0–200 hPa, and the accuracy is 0.5%. The oven is supplied with natural gas (methane) at nominal pressure (20 mbar), and the flowrate of the gas was measured by a gas meter with a 0.025–5 m^3/h range. The measurement equipment and data logger were calibrated before the tests. Due to the uncertainty of the measurement equipment, an uncertainty analysis was held, and the overall uncertainty of the experiments was 2.8%, which is acceptable for an experimental study.

The thermocouple measuring the oven temperature was positioned at the geometric center of the cavity, as shown in Fig. 3. The thermocouples measuring brick temperature were positioned in the brick, as shown in Fig. 2. Since in all experiments the thermocouples were placed in the position specified in the measurement standard, the placement did not effect the measurement accuracy.

3.1 Experimental Results. Figure 4 shows the change in temperature measured inside the brick over time. The temperature at the center of the brick reached 55 K in 3381 s.

The change of center temperature over time of the screw-joined oven is shown in Fig. 5. As seen from the figure, the oven temperature increased rapidly within an average of 1500 s and then stabilized at 180 K, indicating steady-state conditions. Gas consumption was measured, and the corresponding energy consumption was calculated.

3.2 Determination of the Gas Energy Consumption. EN 15181: 2017 + A1:2020 provides the method to calculate the

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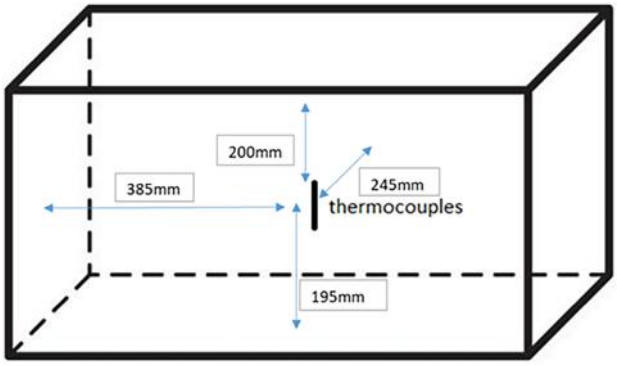


Fig. 3 Thermocouple position in the cavity

energy consumption of ovens [22]. The gas energy consumption, E_k^i, is determined using the following equation:

$$E_k^i = V_c.H_s \tag{1}$$

where E_k^i is the gas energy consumption; V_c is the volume of dry gas consumed, corrected to reference conditions (15 °C and 1013,25 mbar), in cubic meters; and H_s is the gross calorific value of the dry test gas under reference conditions (15 °C and 1013,25 mbar), in megajoule per cubic meter.

V_c is determined from the measured volume by the following formula:

$$V_c = V_{\text{mes}} \cdot \frac{p_a + p - p_w}{1013.25} \cdot \frac{288.15}{273.15 + t_g} \tag{2}$$

where V_{mes} is the measured gas volume (m^3), p_a is the atmospheric pressure (mbar), p is the gas supply pressure measured at the same point as that used in the heat input determination (mbar), p_w is the partial vapor pressure (mbar), and t_g is the gas temperature measured at the same point as that used in the heat input determination (°C).

Regulation (EU) N. 66/2014 provides the method to calculate the energy efficiency index (EEI) of ovens [23].

$$\text{SEC}_{\text{gas cavity}} = 0.044.V + 3.53 \tag{3}$$

where $\text{SEC}_{\text{gas cavity}}$ is the standard energy value consumed by a domestic oven during a cycle under standard load (mJ) and V is the volume of the compartment of the domestic oven expressed in liters.

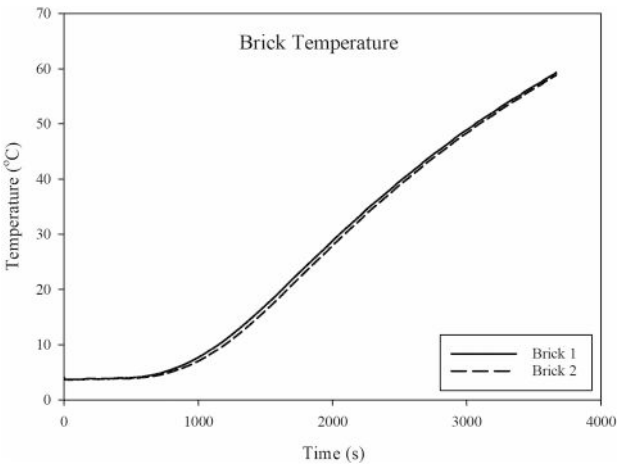


Fig. 4 Change of temperature measured inside the brick over time

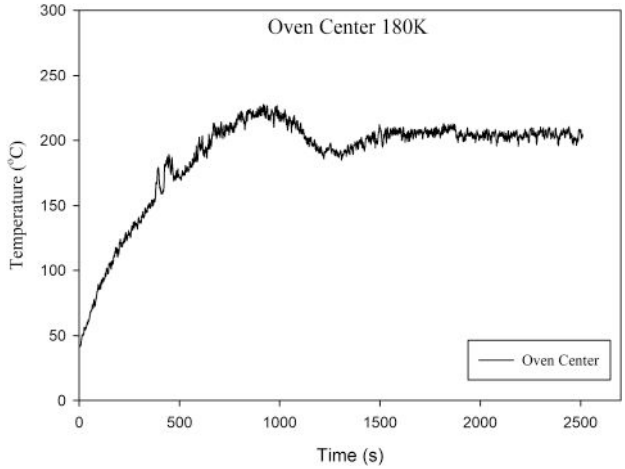


Fig. 5 Temperature rise measured from the center of a domestic oven over time

Table 3 Energy efficiency classes of domestic ovens

Energy efficiency class	Energy efficiency index ($\text{EEI}_{\text{cavity}}$)
A+++ (most efficient)	$\text{EEI}_{\text{cavity}} < 45$
A++	$45 \le \text{EEI}_{\text{cavity}} < 62$
A+	$62 \le \text{EEI}_{\text{cavity}} < 82$
A	$82 \le \text{EEI}_{\text{cavity}} < 107$
B	$107 \le \text{EEI}_{\text{cavity}} < 132$
C	$132 \le \text{EEI}_{\text{cavity}} < 159$
D (least efficient)	$\text{EEI}_{\text{cavity}} \ge 159$

$$\text{EEI}_{\text{cavity}} = \frac{\text{EC}_{\text{gas cavity}}}{\text{SEC}_{\text{gas cavity}}} \times 100 \tag{4}$$

where $\text{EC}_{\text{gas cavity}}$ is the energy value consumed by a domestic oven during a cycle under the standard load (mJ) and $\text{EEI}_{\text{cavity}}$ is the energy efficiency index for ovens.

Table 3 presents the correlation between EEI and the energy efficiency class (Regulation (EU) N. 65/2014) [24].

3.3 Evaluation of Carbon Emission. The ovens with welded and screwed cavities have different energy consumption performances that yield different carbon emissions. The life cycle assessment method is partially used to determine the carbon footprint of the products. This method considers four stages for a product: extracting and processing raw materials, manufacturing and packaging, use and operation during its lifetime, and disposal at the end of its useful life [25]. Both ovens are of the same construction and have the same features except for the cavity joining technique. Carbon emissions at the three stages of the product were assumed to be the same. Therefore, only carbon emission at the product use stage is included in this study. As oven use frequency, nonintensive and intensive use has been taken into consideration, which are 110 cycles/year and 260 cycles/year [6]. Ten years of average lifetime has been considered [5]. The amount of released CO_2 produced is obtained by Eq. (5) [26]:

$$\text{Emissions}_{\text{GHG,Fuel}} = \text{Fuel Consumption}_{\text{fuel}}.\text{Emission Factor}_{\text{GHG,fuel}} \tag{5}$$

where $\text{Emissions}_{\text{GHG, Fuel}}$ is emission of a given GHG (greenhouse gas) (kg), $\text{Fuel Consumption}_{\text{fuel}}$ is the amount of fuel

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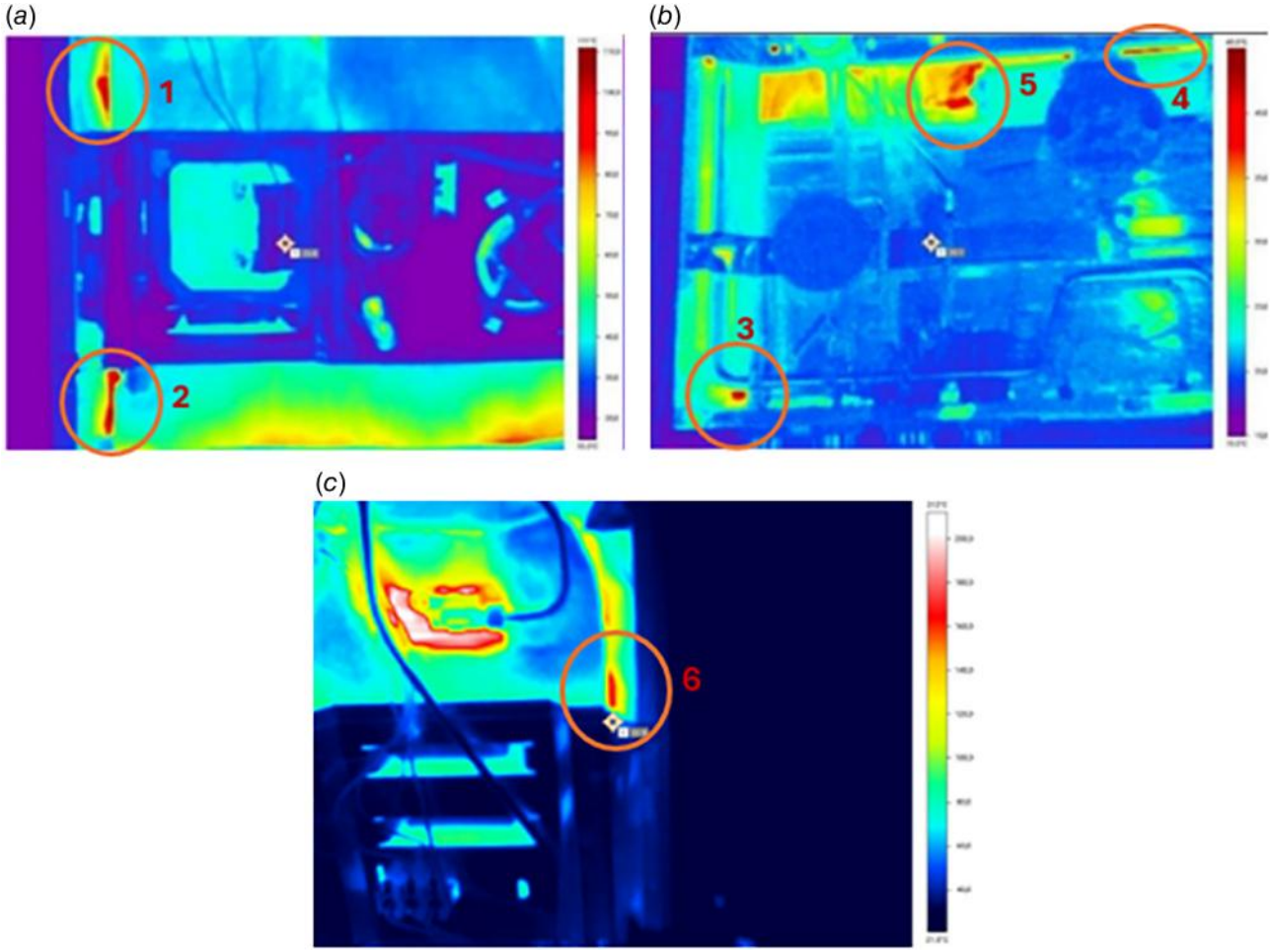


Fig. 6 Thermal camera image in the cavity of a domestic oven with a screw-connected cavity: (*a*) left back, (*b*) top, and (c) right back

combusted (MJ), and *Emission* $\text{Factor}_{\text{GHG, fuel}}$ is the country-specific emission factor (kg gas/MJ).

Concerning the location's influence on consumer preferences, carbon dioxide emissions were calculated for different countries from different continents. Country-specific carbon dioxide emission factors were obtained from 2006 IPCC Guidelines and BEIS 2020 [26,27].

4 Results and Discussion

Thermal camera images were taken during the tests of two ovens to show the effect of the joining technique on heat leaks from the cavity to the surroundings. Therefore, heat leak especially from the screw-joined oven was observed clearly.

In Fig. 6, thermal camera images from the back, top, and side surfaces of the gas oven with a screwed cavity are given. Heat leaks can be clearly seen in the areas marked (1–6) on the images. Especially from the parts between the screwed connections, heat transfers to the environment. Nonhomogeneous thermal expansions during the heating and cooling of the oven increase these leaks. Although the distance between the screws is reduced, heat still leaks out of the cavity. Moreover, these leaks can fluctuate as the oven is used, causing irregular heat loss.

In Fig. 7, thermal camera images of the gas oven with a welded cavity are given. The images were taken from the back, top, and side surfaces during the tests. In the oven with screwed cavity, the heat leaks seen in the screwed connection were not observed areas marked (1–5) on the images. Moreover, there are no heat leaks, even in cases where there is thermal expansion when the oven is heated or cooled. The increase in these heat leaks is not significant upon repeating the experiments. This demonstrates the superiority of the welded connection.

The thermal camera images taken from the exact directions of both ovens are given side by side in Fig. 8. A schematic oven model and the connection points of the cavity are given on the left side of Fig. 8. Screw connection points and heat leaks from these points (1–3) can be seen in Fig. 8(*a*). Figure 8(*b*) shows that there are not any heat leaks in the exact location (4–6) of the welded cavity.

It was observed during the tests that there were fluctuations in gas consumption, especially in the oven with the screw joint cavity. In the experiments conducted for 140 K, a minimum of 0.238 m^3, a maximum of 0.319 m^3, and an average of 0.274 m^3 of gas fuel were used (Fig. 9(*a*)). In the experiments conducted for 180 K, a minimum of 0.251 m^3, a maximum of 0.306 m^3, and an average of 0.281 m^3 of gas fuel were used (Fig. 9(*b*)). In the experiments conducted for 220 K, a minimum of 0.267 m^3, a maximum of 0.324 m^3, and an average of 0.300 m^3 of gas fuel were used (Fig. 9(*c*)).

Although the amount of gas used in the welded joint oven does not change as much as in the screw joint oven, small changes are observed for this oven as well. In the experiments conducted for 140 K, a minimum of 0.221 m^3, a maximum of 0.256 m^3, and an average of 0.235 m^3 of gas fuel were used (Fig. 10(*a*)). In the experiments conducted for 180 K, a minimum of 0.236 m^3, a maximum of 0.259 m^3, and an average of 0.247 m^3 of gas fuel were used (Fig. 10(*b*)). In the experiments conducted for 220 K, a minimum of 0.242 m^3, a maximum of 0.275 m^3, and an average of 0.261 m^3 of gas fuel were used (Fig. 10(*c*)). In

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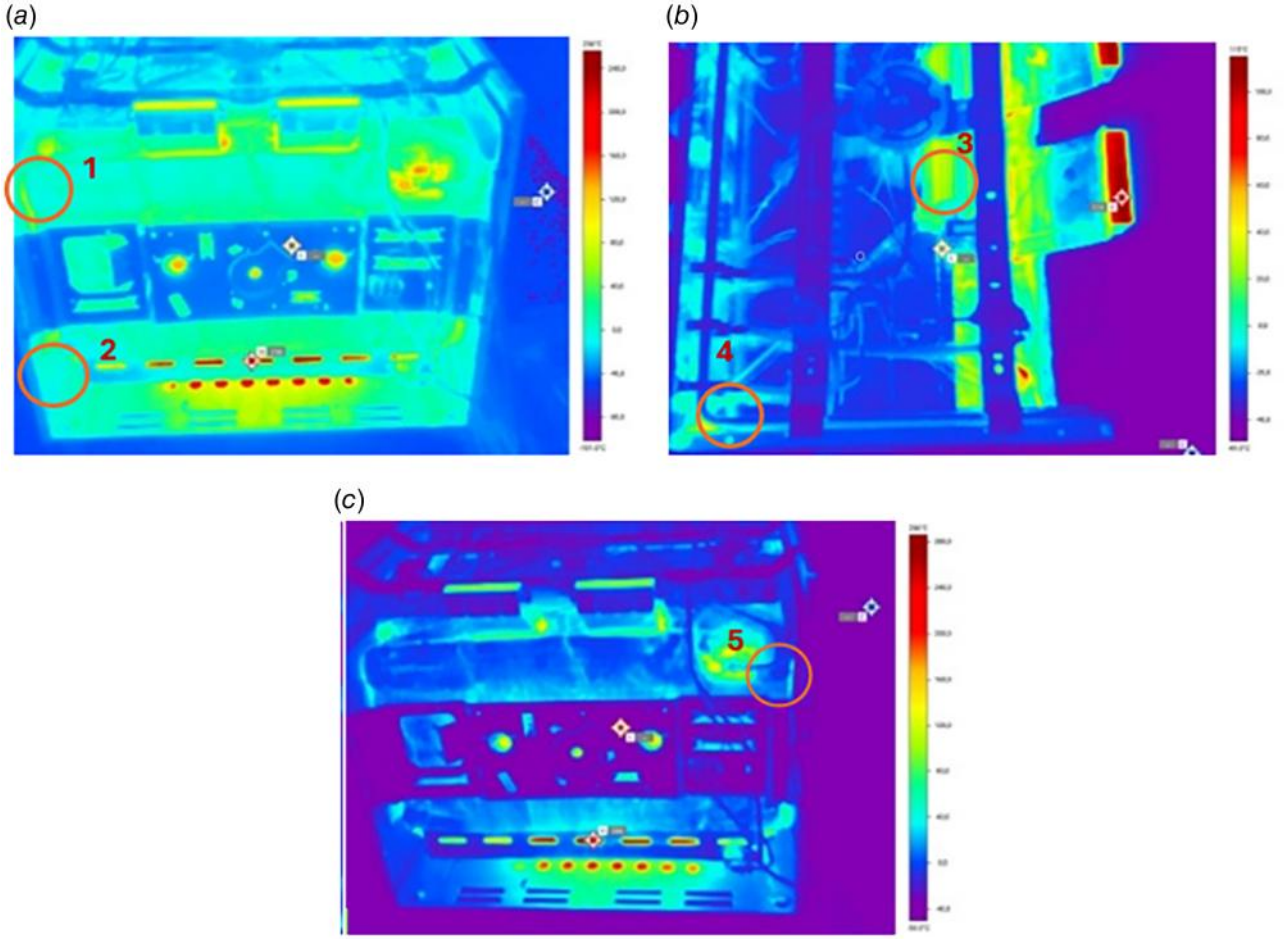


Fig. 7 Thermal camera image of a domestic oven cavity with a welded-connected cavity: (*a*) left back, (*b*) top, and (*c*) right back

the calculations made by taking the averages into account, the decrease in the gas consumption in the welded joint oven was calculated as 14.22% for 140 K, 12.00% for 180 K, and 12.72% for 220 K.

Figure 10 shows the results obtained from the experiments conducted for 140 K, 180 K, and 220 K according to the calculated gas energy consumption values. Figure 10 shows changes similar to Fig. 9, where the gas consumption values are given.

The EEI is calculated using Eq. (4) for both ovens (Fig. 11). The EEI for the oven with a screw-joined cavity ranged from a minimum of 101.69 to a maximum of 123.45, with an average of 112.92. For the oven with a welded connection, the EEI ranged

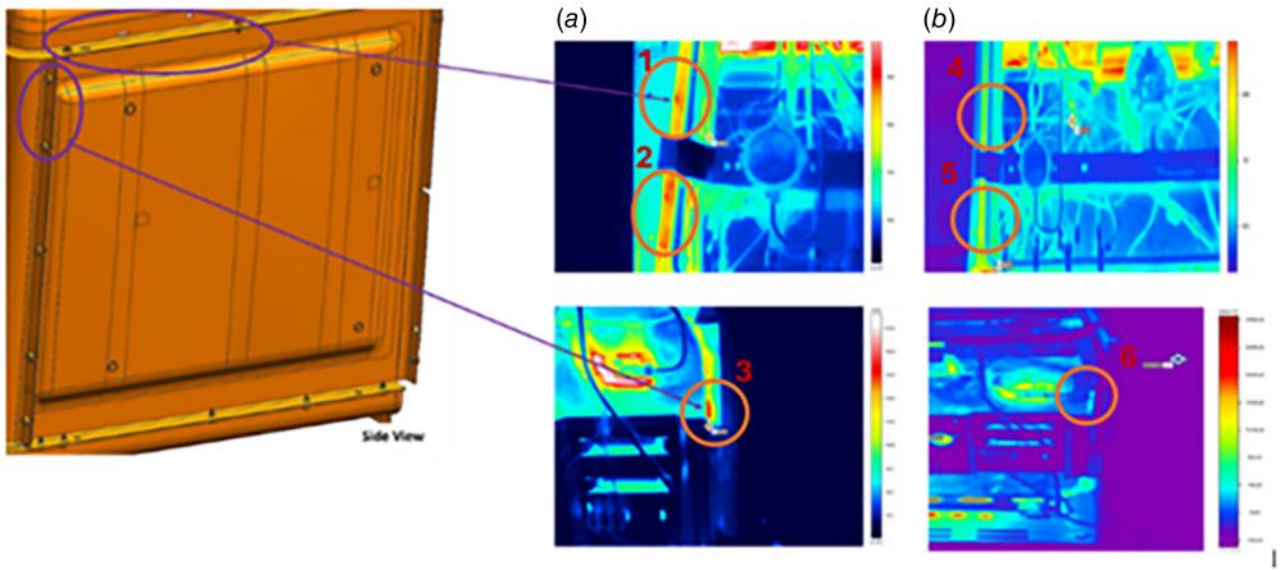


Fig. 8 Thermal camera image comparisons of domestic ovens with screwed and welded connections: (*a*) screwed cavity (top and right back views) and (*b*) welded cavity (top and right back views)

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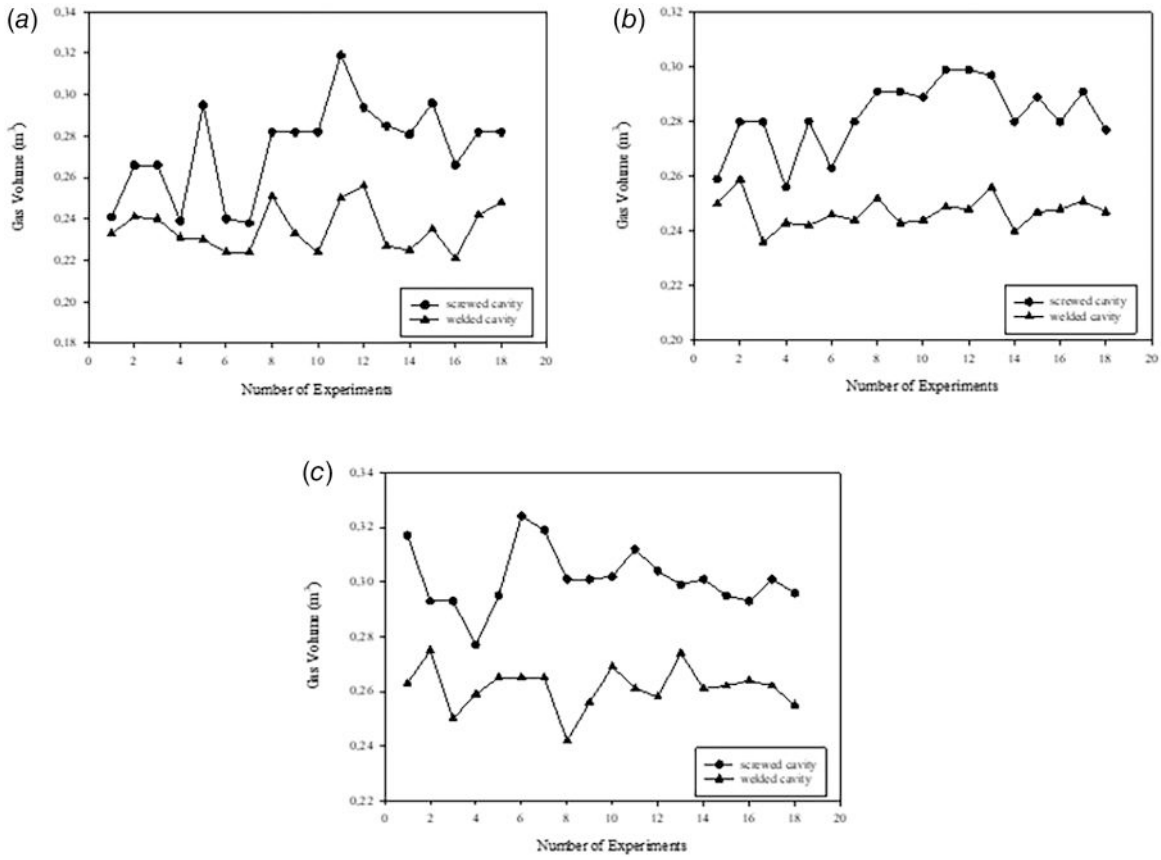


Fig. 9 Volume of gas consumption: (*a*) 140 K, (*b*) 180 K, and (c) 220 K

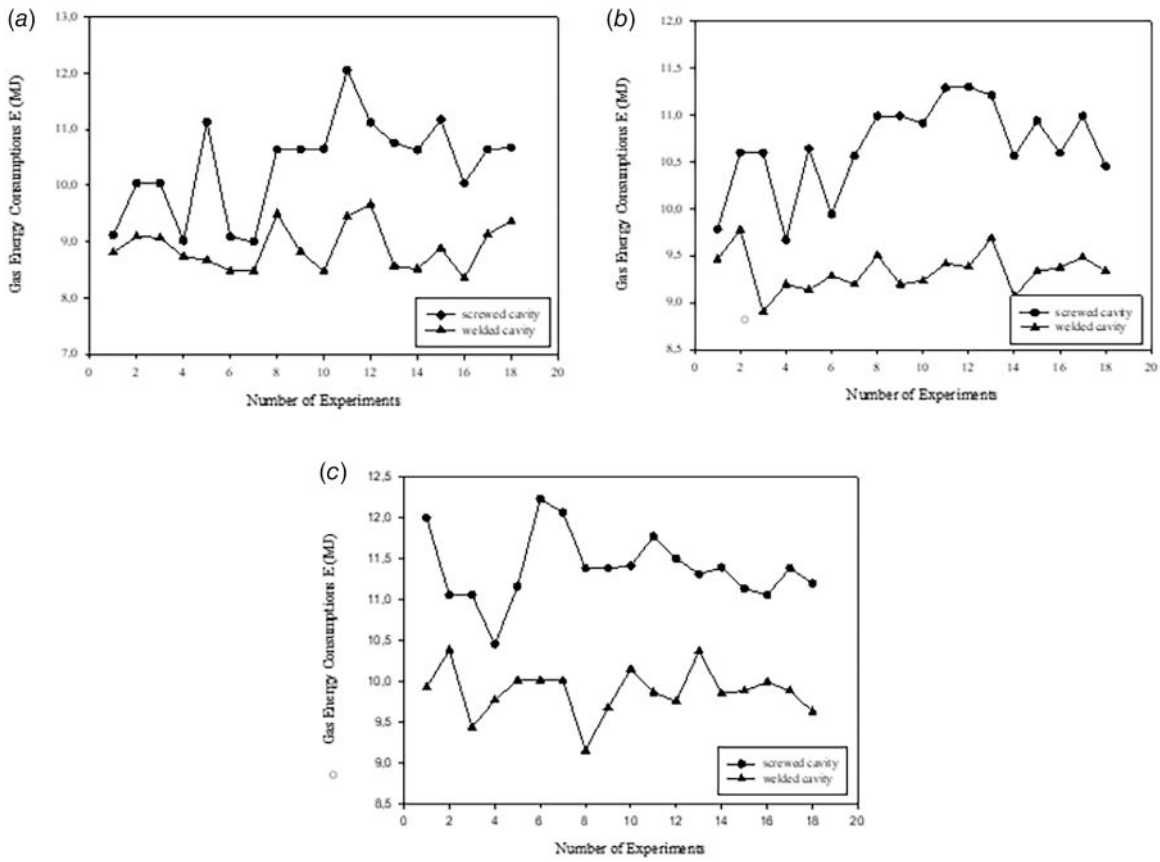


Fig. 10 Calculated energy consumption (*E*): (*a*) 140 K, (*b*) 180 K, and (*c*) 220 K

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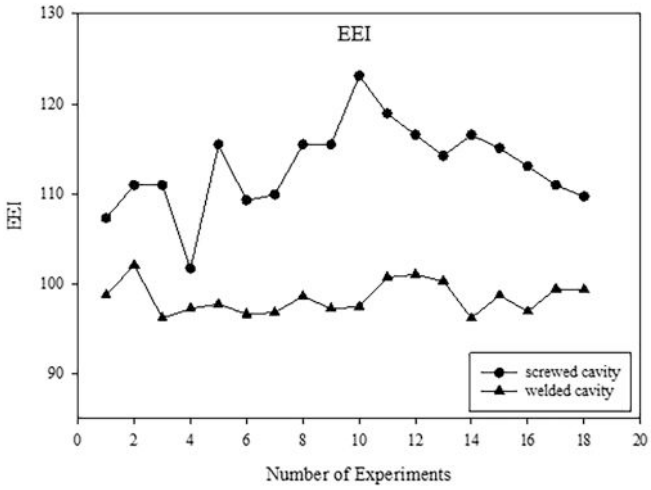


Fig. 11 Calculated energy efficiency index (EEI) value

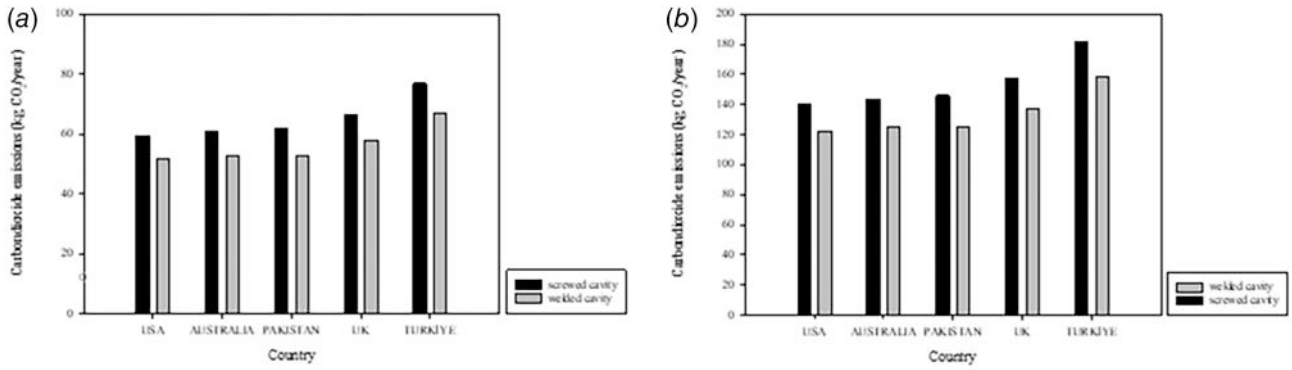


Fig. 12 Annual CO_2 emissions: (*a*) nonintensive use and (*b*) intensive use

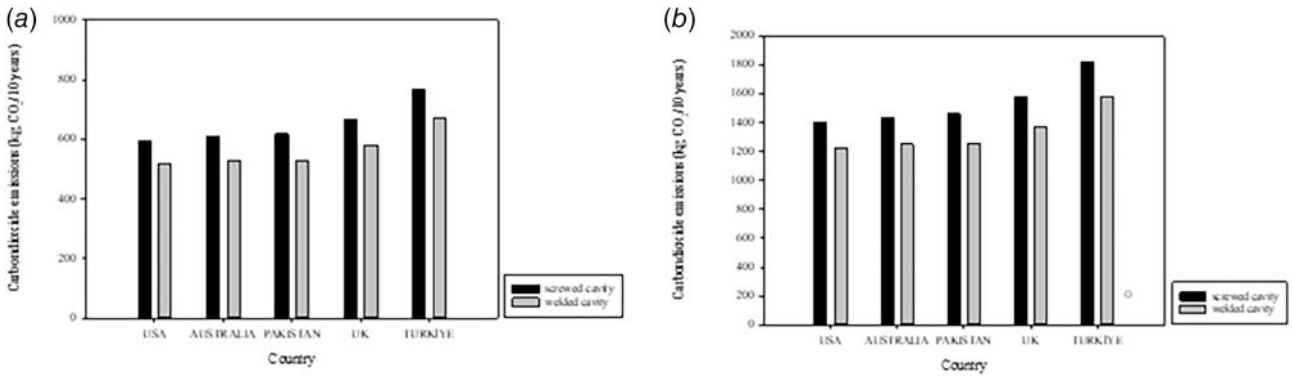


Fig. 13 10-year CO_2 emissions: (*a*) nonintensive use and (*b*) intensive use

from a minimum of 96.16 to a maximum of 102.05, with an average of 98.38. On average, there was a 12.88% decrease in the EEI for the oven with a welded connection compared to the oven with a screw connection.

Carbon dioxide emissions with nonintensive and intensive use per year are shown in Fig. 12. It can be seen that the carbon dioxide emission of ovens with screwed cavities is 12.92% higher than that of ovens with welded cavities due to excess fuel consumption. Carbon dioxide emissions over the lifetime of the appliances are shown in Fig. 13.

5 Conclusions

In oven manufacturing, joining cavities with screws can be preferred for its ease and cost-effectiveness. Welded connections are both more challenging to manufacture and more expensive than screwed connections. However, even if the distance between the screws is kept short in screwed connections, primarily when the ovens work at high temperatures, the material expands at these temperatures, and heat leaks from the gap between the screws. In addition, as use increases, these thermal expansions become much more irregular, and heat losses gradually increase. These heat losses in welded connections are less than in ovens made with screw connections and do not increase with the intense use.

- During the experimental studies, thermal camera images of the furnaces with screw and welded joints were examined, and it was observed that there was heat leakage from the gaps between the screws, especially in the oven with screw joints.

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- In the tests carried out according to the BS EN 15181: 2017 + A1-2020 standard, and gas consumption is 12–14.22% less in ovens made with welded connections than in ovens made with screw connections. Gas energy consumption also decreases at the same rate.
- According to the experimental results, EEI was calculated as a minimum of 101.69, a maximum of 123.45, and an average of 112.92 in ovens made with screw connections. In ovens made with welded connections, EEI was calculated as a minimum of 96.16, a maximum of 102.05, and an average of 98.38.
- The calculated EEI of the oven with a screw connection resulted in energy class ratings of A, B, and B for minimum, average, and maximum values, respectively. On the other hand, the oven with a welded connection obtained energy class ratings of A, A, and A in the same order. This shows that the oven with a welded connection is more energy efficient, as it received a higher energy class rating (A) compared to the oven with a screw connection (B). Therefore, choosing an oven with a welded connection would lead to lower energy consumption for the consumer.
- The CO_2 emission factor varies between countries based on the natural gas supply method. Upon examining the environmental effects, it was found that Turkey has the highest CO_2 emissions for both screwed and welded connections, followed by the United Kingdom, Pakistan, Australia, and the United States, respectively. There is a 12.92% greater release of CO_2 in screw-connected ovens compared to welded-connected ovens.

The increasing cost of energy access is compelling people to use energy more efficiently. Supply, transportation, conversion, and efficient energy use are important issues. In our world, where energy saving is gaining importance, both the publication of regulations by international authorities to reduce energy consumption and the conscious demand of consumers for devices that consume less energy have forced manufacturers to produce more efficient appliances. The ease of production of a device and its low production cost are essential parameters, but they are still in the background next to the level of energy efficiency.

The study examined how the manufacturing technique of a gas-fired oven affects gas consumption and the environment. The results demonstrated that even a small improvement in the oven's assembly technique could lead to an energy class change and a reduction in carbon emissions through decreased gas consumption.

In the future, the impact of using sealing elements such as silicone and gaskets between metal materials in screw connections will be investigated.

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Conflict of Interest

There are no conflicts of interest.

Data Availability Statement

Data provided by a third party listed in Acknowledgment.

References

[1] Hoxha, E., and Jusselme, T., 2017, "On the Necessity of Improving the Environmental Impacts of Furniture and Appliances in Net-Zero Energy Buildings," Sci. Total Environ., **596–597**, pp. 405–416.
[2] Amienyo, D., Doyle, D., Gerola, D., Santacatterina, G., and Azapagic, A., 2016, "Sustainable Manufacturing of Consumer Appliances: Reducing Life Cycle Environmental Impacts and Costs of Domestic Ovens," Sustain. Prod. Consum., **6**, pp. 67–76.
[3] Lucchi, M., Suzzi, N., and Lorenzini, M., 2019, "Dynamic Model for Convective Heating of a Wet Brick During Energy Characterisation of Domestic Electric Ovens," Appl. Therm. Eng., **161**, p. 114117.
[4] Mistry, H., Ganapathisubbu, S., Dey, S., Bishnoi, P., and Castillo, J. L., 2010, "A Methodology to Model Flow-Thermals Inside a Domestic Gas Oven," Appl. Therm. Eng., **31**(1), pp. 103–111.
[5] Rodriguez Quintero, R., Bernad Beltran, D., Ranea Palma, A., Donatello, S., Villanueva Krzyzaniak, A., Paraskevas, D., Boyano Larriba, A., and Stamminger, R., 2022, "Preparatory Study of Ecodesign and Energy Labelling Measures for Domestic Cooking Appliances," EUR 31250 EN, Publications Office of the European Union, Luxembourg, Online, JRC130716.
[6] Landi, D., Consolini, A., Germani, M., and Favi, C., 2019, "Comparative Life Cycle Assessment of Electric and Gas Ovens in the Italian Context: An Environmental and Technical Evaluation," J. Clean. Prod., **221**, pp. 189–201.
[7] Mistry, H., Dey, S., Bishnoi, P., and Castillo, J. L., 2006, "Modeling of Transient Natural Convection Heat Transfer in Electric Ovens," Appl. Therm. Eng., **26**(17–18), pp. 2448–2456.
[8] Smolka, J., Bulinski, Z., and Nowak, A. J., 2013, "The Experimental Validation of a CFD Model for a Heating Oven With Natural Air Circulation," Appl. Therm. Eng., **54**(2), pp. 387–398.
[9] Capablo, J., and Garcia-Polanco, N., 2013, "Modeling of Energy Performance of a Domestic Oven: Experimental Validation," John Doyle 8th World Conference on Experimental Heat Transfer, Fluid Mechanics, and Thermodynamics, Lisbon, Portugal, June 16–20.
[10] Das, M., Ganguly, R., Datta, A., Verma, M. M., and Bera, A. K., 2019, "Computational Fluid Dynamic Analyses of Flow and Combustion in a Domestic Liquefied Petroleum Gas Cookstove Burner—Part II: Burning Characteristics and Overall Performance," ASME J. Therm. Sci. Eng. Appl., **12**(3), p. 031011.
[11] Das, M., Ganguly, R., Datta, A., Verma, M. M., and Bera, A. K., 2020, "Performance Improvement of a Domestic Liquefied Petroleum Gas Cook Stove Using an Extended Spill-Tray and an Annular Metal Insert," ASME J. Therm. Sci. Eng. Appl., **13**(2), p. 021016.
[12] Silva, R. L., Sant′Ana, B. V., Patelli, J. R., and Vieira, M. M., 2017, "Performance Improvements in Cooker-Top Gas Burners for Small Aspect Ratio Changes," ASME J. Therm. Sci. Eng. Appl., **9**(4), p. 044503.
[13] Özdemir, İ. B., 2017, "Simulation of Turbulent Combustion in a Self-Aerated Domestic Gas Oven," Appl. Therm. Eng., **113**, pp. 160–169.
[14] Carson, J. K., Willix, J., and North, M. F., 2006, "Measurements of Heat Transfer Coefficients Within Convection Ovens," J. Food Eng., **72**(3), pp. 293–301.
[15] Park, S. H., Kim, Y. H., Kim, Y. S., Park, Y. G., and Ha, M. Y., 2018, "Numerical Study on the Effect of Different Hole Locations in the Fan Case on the Thermal Performance Inside a Gas Oven Range," Appl. Therm. Eng., **137**, pp. 123–133.
[16] Landi, D., Cicconi, P., and Germani, M., 2019, "A Design Methodology for the Virtual Energy Labelling of Cooking Ovens," Int. J. Interact. Des. Manuf., **13**(3), pp. 851–871.
[17] Kodal, A. I., Yilmaz, E. C., and Kapkin, S., 2024, "Flame Deflector Modification for Improved Combustion Efficiency in Domestic Gas Ovens," Combust. Sci. Technol., **197**(9), pp. 2098–2115.
[18] Ryu, J., Kwon, J., Kim, R., Kim, M., Kim, Y., Jeon, C., and Song, J., 2014, "Surface Ignition Behaviors of Methane–Air Mixture in a Gas Oven Burner," Appl. Therm. Eng., **65**(1–2), pp. 262–272.
[19] Suryanto, E., and Armunanto, R., 2014, "The Effect of Heating Process Using Electric and Gas Ovens on Chemical and Physical Properties of Cooked Smoked-Meat," Proc. Food Sci., **3**, pp. 19–26.
[20] Hincapié, F. F., and García, M. J., 2024, "A Surrogate Model of Heat Transfer Mechanism in a Domestic Gas Oven: A Numerical Simulation Approach for Premixed Flames," Appl. Mech., **5**(2), pp. 391–404.
[21] Mudgal, S., Tinetti, B., Hoa, E., Audard, G., Robertson, C., Goodman, P., and Pitman, S., 2011, "Preparatory Studies for Ecodesign Requirements of EuPs (III). Lot 22. Domestic and Commercial Ovens (Electric, Gas, Microwave), Including When Incorporated in Cookers. Lot 23. Domestic and Commercial Hobs and Grills, Included When Incorporated in Cookers."
[22] European Standart EN 15181: 2017 + A1:2020, Measuring Method of the Energy Consumption of Gas Fired Ovens.
[23] Official Journal of the European Union, "Regulation (EU) N. 66/2014 of 1 January 2014 Implementing Directive 2009/125/EC of the European Parliament and of the Council With Regard to Ecodesign Requirements for Domestic Ovens, Hobs and Range Hoods," https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0066, Accessed October 15, 2024.
[24] Official Journal of the European Union, "Regulation (EU) N. 65/2014 of 1 October 2013 Supplementing Directive 2010/30/EU of the European Parliament and of the Council With Regard to the Energy Labelling of Domestic Ovens and Range Hoods," https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0065, Accessed October 15, 2024.
[25] Springer Singapore Pte. Limited, 2021, *LCA Based Carbon Footprint Assessment*, S. S. Muthu, ed., ProQuest Ebook Central, Singapore, https://ebookcentral.proquest.com/lib/yildiz/detail.action?docID=6458047
[26] IPCC, 2006, *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme*, H. S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe, eds., IGES, Japan.
[27] BEIS, 2020, "Government Emission Conversion Factors for Greenhouse Gas Company Reporting," https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting, Accessed October 15, 2024.

http://asmedigitalcollection.asme.org/thermalscienceapplication/article-pdf/doi/10.1115/1.4070218/7555283/tsea-25-1034.pdf?casa_token=UxPZNguC4NsAAAAA:oBVp54au4R8KGFTzEq8cUmhlqtypanBUJAQkAk6sq34QaO6bmlk6LXgqPCONXzi7YofnKNGasg by Yildiz Teknik Universitesi user on 1