Thermal behaviour of synthetic countertop used as cooker surface over induction hobs

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Abstract—**In recent years, domestic induction hobs have become very popular due to their excellent performance, easy cleaning process, safety and high efficiency [1]. Currently, most induction hobs are placed inside a hole dug into the kitchen countertop. This approach, which is mandatory for traditional gas cooktops, can easily be avoided by installing the induction hob under the countertop. In fact, induction heating appliances transfer power to the pot via electromagnetic coupling and the heating of the magnetic steel bottom is achieved through the circulation of eddy currents. This way, the surface of the cooker is heated only by the pot and usually reaches relatively low temperatures. A key factor in the design of this type of solution is the choice of material for the countertop, which should have good mechanical and thermal properties in order to endure the typical temperatures reached in the cooking process. Many different materials have been taken into account, such as marble, quartz and granite [2].**

In this paper, a popular material used for synthetic countertops, Corian© manufactured by DuPont, is proposed as a possible solution for the use of the induction cooker under the kitchen counter.

Keywords— induction hob, kitchen countertop, cooktop, induction heating, countertop material, Corian© solid surface

I. Introduction

Corian© is a brand of solid surface material developed by DuPont and is mainly composed of polymethyl methacrylate (34-45%) and aluminum trihydroxide (55-66%) [3]. Some experimental tests were conducted to characterize the behaviour of this material under the typical thermal stresses produced while cooking. The experimental set-up used for the tests comprises: a portable induction hob with a rated power of 2 kW, a pot with a top diameter of 22 cm and a bottom diameter of 18 cm and a 12 mm thick slab of white Corian©. A data acquisition system, composed of a digital data logger and a personal computer, recorded at regular time intervals the temperatures measured by a series of thermocouples installed in different positions along the solid surface and the pot.

II. Test with Boiling Water

Five thermocouples were installed on the upper surface of the Corian© slab at different distances from the pot and one additional thermocouple was fixed to its bottom. The pot was filled with 4 litres of water and placed directly onto the solid surface slab. The pot was heated up until it reached 100 °C and the water was left boiling for a total of 90 minutes before switching off the induction hob. Temperatures were measured and stored once per minute.

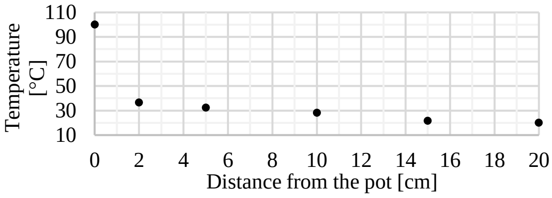

Fig. 1. Temperature of the solid surface as a function of the distance from the pot after 90 minutes of boiling.

Fig. 1 shows the temperature on the solid surface rapidly decreasing below 40 °C within the first 2 cm. Therefore, users can safely place their hands on the surface around the pot without any risk of burns.

No visible damage was found at the end of the test.

III. Thermal Shock

As it emerged from simple preliminary tests, Corian© has a tendency to deform and yellow slightly around 160 °C. Hence, this temperature was chosen as reference for the subsequent tests.

In order to check if the solid surface could resist sudden temperature variations, the temperature of the pot was raised to 160 °C and maintained for about 41 minutes by manually controlling the power level of the induction hob. Then, the first pot was quickly switched with another pot of the same dimensions containing ice at -10 °C. Temperatures were measured and stored once per second by the data acquisition system. Fig. 2 shows a scheme of the measurement points where the thermocouples were installed, both over and below the surface of the Corian© slab.

As can be seen in Fig. 3, after the swap the temperature measured by the probe T/C 2 placed on the pot boundary dropped about 70 °C in 15 seconds, then dropped below 40 °C within the first minute. The material showed no cracks and the slab retained its integrity. However, permanent yellowish marks were left in correspondance to the pot bottom due to the high temperature. In addition, some bulges and asperities appeared in the area, as shown in Fig. 4.

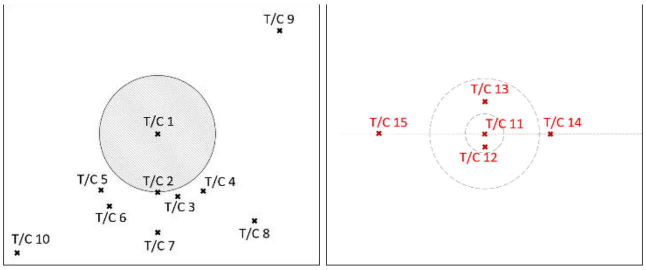

Fig. 2. Positions of the thermocouples over the surface (left) and below the surface (right).

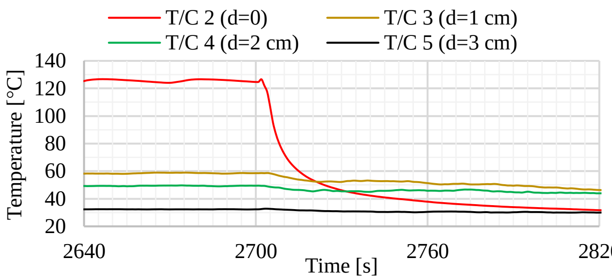

Fig. 3. Temperatures as a function of time in four measurement points over the solid surface during the temperature jump phase.

TABLE I. Temperatures on Probe T/C 2

Time [s]	2702	2717	2732	2762
Temperature [°C]	126.540	56.959	45.336	37.444

Fig. 4. Picture of the damages left to the surface after the test (the photo has been treated to enhance the effect, otherwise inappreciable).

IV. Test with a Silicone Mat under the Pot

In view of the previous results, a silicone mat with a thickness of 3 mm was interposed between the Corian© slab and the pot to try to prevent damages to the surface. Six thermocouples were installed inside the pot at different radial distances from the center. Six thermocouples were placed under the mat at the same radial distances. Note that, in this experiment, the positions of the thermocouples are different from those reported in Fig. 2. Table II shows the distance of each probe from the center of the pot. The test consisted of five steps. At each step, the temperature of the pot was raised to a predetermined value and maintained for a given time period. Among the thermocouples placed on the pot bottom, the one with the highest temperature reading (B5) was considered for the manual control of the temperature. This leads to much lower temperatures at the center of the pot, compared to the previous test. Table III shows the temperature values and the duration of each step. A real-time plot can be seen in Fig. 5.

TABLE II. Distance of the Probes from the Center of the Pot

N.							
N.	Bottom	B1	B2	B3	B4	B5	B6
N.	Mat	M7	M8	M9	M10	M11	M12
Distance [cm]		0	2	4	6	8	9

TABLE III. Temperatures and Durations of the Steps

Step number	1	2	3	4	5
Temperature [°C]	160	170	180	190	200
Duration [min]	30	30	30	15	15

During the first three steps, the temperature under the silicone mat did not exceed 160 °C throughout the whole area, as can be seen in Fig. 7. When the highest temperature on the pot base exceeded 180 °C, the 160 °C threshold was surpassed below the mat.

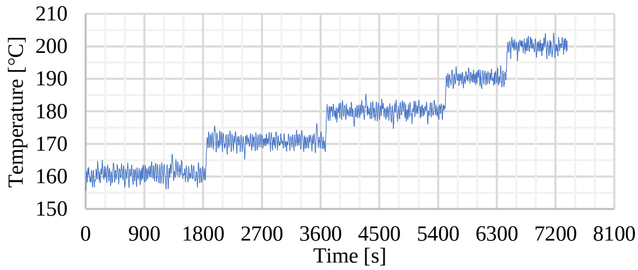

Fig. 5. Temperature on B5 as a function of time.

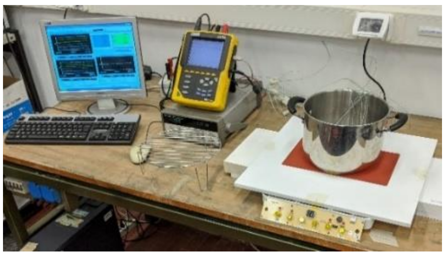

Fig. 6. Experimental set-up.

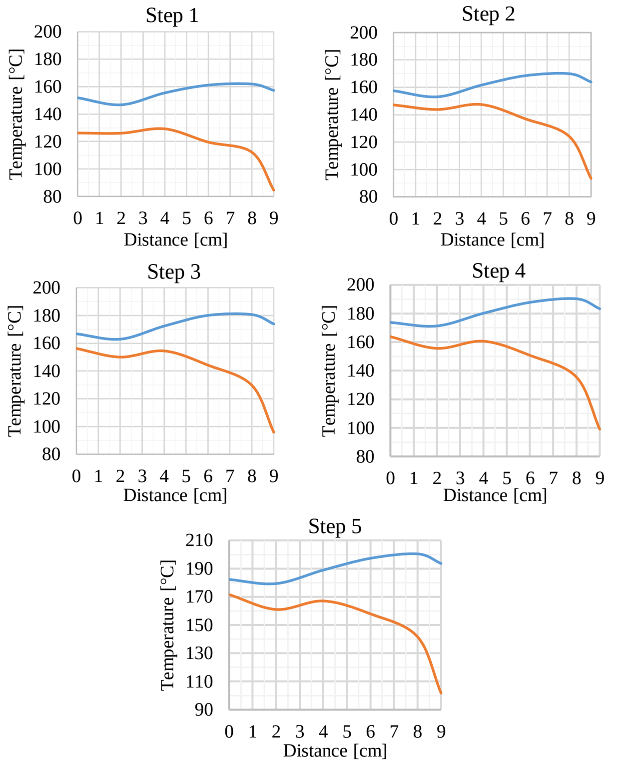

Fig. 7. Temperature as a function of the distance from the center of the pot under the silicone mat (orange line) and on the pot bottom (blue line).

V. Conclusion

In all the tests, the slab of Corian© showed good overall mechanical performances. In fact, no visible cracks were found on the cooktop after experimenting intense thermal stress. However, a problem of local deformation and yellowing emerged at around 160 °C. Thus, for high temperature preparations (i.e. frying), cooking with an insulation mat under the pot is highly recommended. A 3 mm thick silicone mat was used to correlate the temperature of the pot with the temperature on the solid surface. In order to keep the temperature on the Corian© slab below 160 °C, the pot should not exceed temperatures greater than 180 °C. For some recipes, like deep-fried foods, the temperatures involved can range between 175 °C and 190 °C. Hence, some kind of control is required. For example, some sensors located inside the mat could prevent the induction hob from feeding the pot when the mat is not in place or the temperature reaches dangerous values. Alternatively, one could adopt some easier solutions like a more performing insulation material, a thicker silicone mat or a raised pot equipped with supporting feet. However, none of these solutions eliminates the risk associated to user errors. If the mat is not placed or a conventional pot is used, the surface could be damaged. In addition, increasing the mat thickness lowers the power transferred to the pot and, thus, the efficiency of the system.

References

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