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ANALITICAL-EXPERIMENTAL COMPARATIVE STUDY OF A DEVICE DESTINED TO FOOD HEATING BY ELETROMAGNETIC INDUCTION

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Abstract*. This article aims at making a comparative study to a system for heating food in air-cooled environments. The study was conducted by merging an analytical and experimental approach. Initially was modeled an ideal simplified unidirectional heating system on a permanent basis, aiming to get the thermal energy needed to compensate the heat loss to the environment. At the same time it was carried out a laboratory experiment with controlled temperature using an electromagnetic inductor as the primary source of energy to the system. Thus, it is possible to compare the types of approaches considering their specific constraints and simplifications. After getting all the information, it was concluded that the experimental system provides superior power to the defendant, that since the induction equipment used has cooking function foods and not specifically heating. Therefore, changes in the equipment may pose a way to obtain effective results at the same time viable in the energy and economic point of view.*
Keywords*: Food heating, Heat transfer, Electromagnetic induction.*

1. INTRODUCTION

This article proposes to study an aspect of the mechanism “food heating plate by electromagnetic induction. Since this is a developing product, studies are necessary to verify the technical and financial viability as well as the potential for industrial-scale production.

New possibilities arise to replace the traditional way of food preparation, just like the cooktops, with clear advantages, such as: precise temperature control, fast and uniform heating, timer function, clean design, practicality, easy cleaning and renewable energy use. However, Waitmann (2014) points out that the need of specific pans and the cost of the equipment are negative facts in relation to electric or gas versions, but the popularization o technology may reduce the values.

The general objective is to find, analytically, the heat loss of a heating system composed of thermal resistances and compare with an experiment in controlled environment where the power source is a food cooking equipment that operates by electromagnetic induction with maximum power of 1300W.

2. EXPERIMENTAL PROCEDURE

It is examined the heating of a circular steel sheet with dimensions of (120 x 2)mm and (150 x 2)mm in contact with a glass plate, measuring (150 x 4; 180 x 4; 210 x 4)mm, with an aliment that must be kept close to 54°C in an air-cooled environment with temperatures of 17, 18, 19 and 20°C. However, the experiment was conducted only with the plate of (120 x 2)mm at a temperature of 18°C. Therefore, a system of idealized thermal resistances is compared with an experiment of heating by electromagnetic induction performed in a laboratory, as illustrated in Fig. 1, where “Q” represents the heat transferred. This comparison is very important to the understanding of the differences between an idealized analytical system and an experimental system. Finally, a thermal camera is used to take pictures aiming to help the comprehension of the thermal propagation in the experimentally studied model.

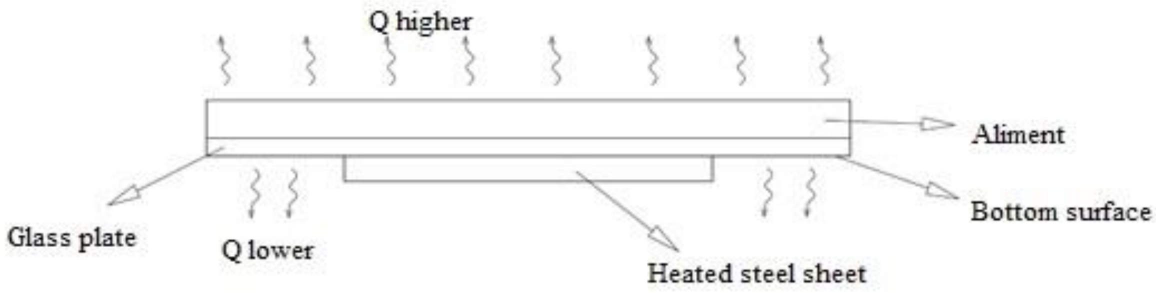

Figure 1. Schematic draw of the system.

2.3 Experimental Analysis

Alongside the analytical calculations, an experiment will be held using an electromagnetic induction equipment as heat source for the heating system. This equipment is the Electrolux Celebrate Cooktop with maximum power of 1300W. A plate was adapted through steel sheet fixation, using epoxy adhesive, in the bottom of it to perform the experiment, as shown in Fig 2.

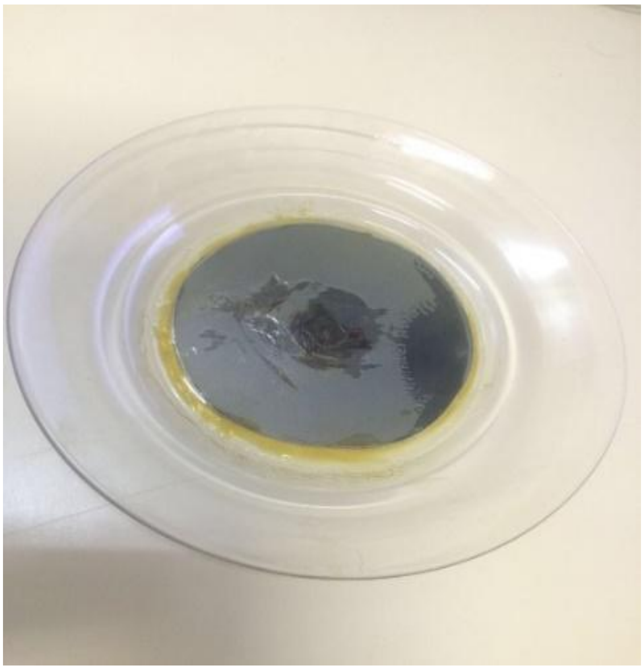

Figure 2. Adapted plate.

3. RESULTS AND DISCUSSION

3.1. Natural convective coefficient

Values of the natural convective coefficient (h) were achieved through calculations, as shown in Fig. 3. It was perceived that the values of “h” did not changed with the geometric configurations used for each temperature considered.

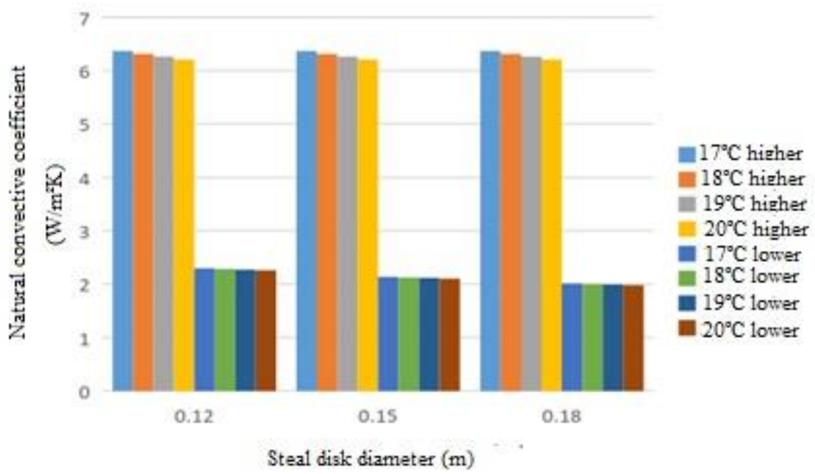

Figure 3. Values of natural convective coefficient for different temperatures

3.2. Thermal circuit and heat transferred

Values of the heat transferred between the heating system and environment were achieved through values of "h" calculated before, as shown in Fig. 4 and 5.

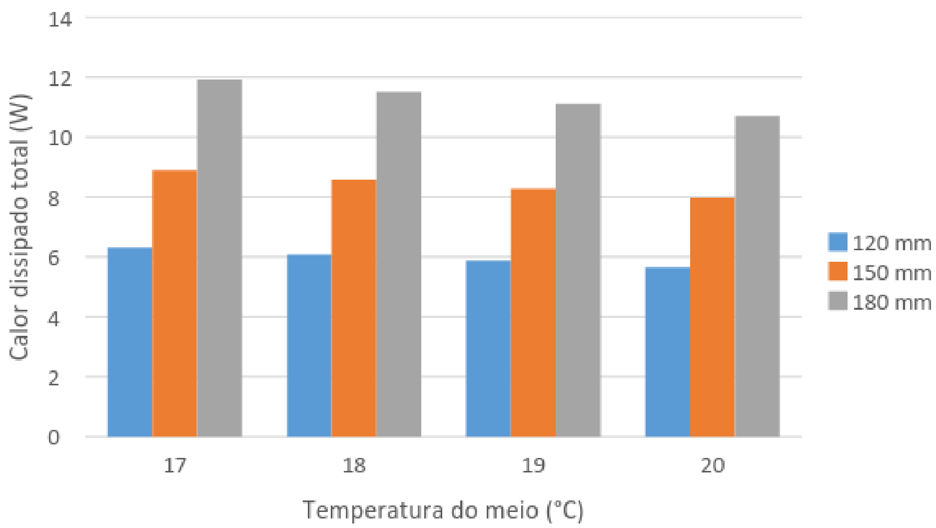

Figure 4. Heat loss of the system to the environment according to the environment temperatures for the diameters of 120, 150 and 180mm with thickness of 4mm.

Increase in the heat loss is easily observed with the increment in the plate diameter due to a greater contact area between the aliment and the surrounding air since this actor depends of the area.

3.3. Experimental Results

Values of temperature in the experiment were obtained through use of a laser thermometer and a thermal camera, considering the aliment exposed to the air (Fig. 5) and with evolvement (Fig. 6), aiming to maximize temperature homogenization

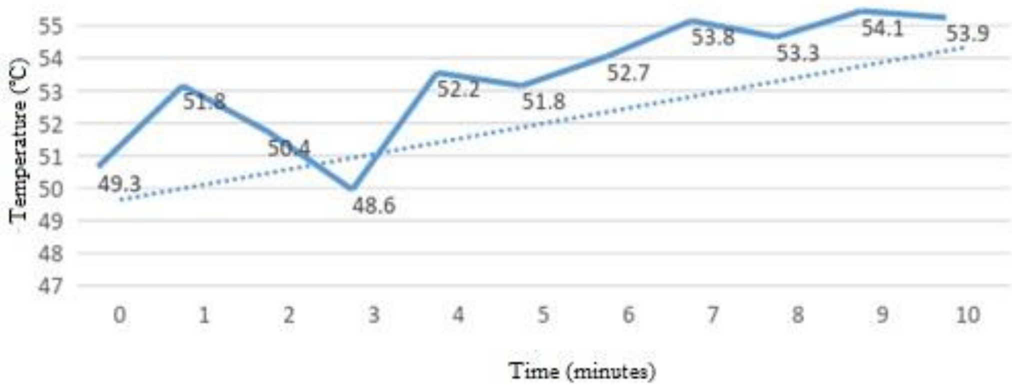

Figure 5. Values of the aliment surface temperature exposed to surrounding air.

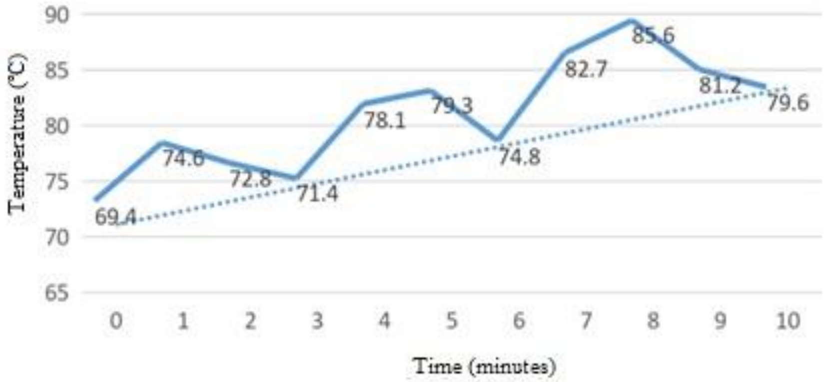

Figure 6. Values of the aliment surface temperature with evolvement.

Although the equipment maximum power was 1300W, it was used the second power level to the measurements. This level is equivalent to 433W available to heating. Fig. 7 and 8 illustrates the measuring moment.

Figure 7. Temperature measurement in the aliment exposed to surrounding air.

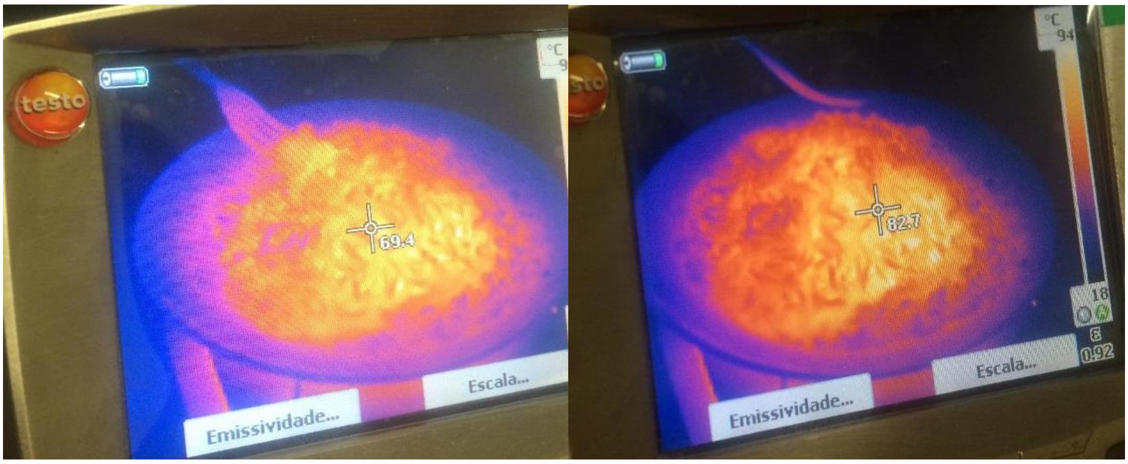

Figure 8. Temperature measurement in the evolved aliment.

Initially, when the aliment was exposed to surrounding air, the surface temperatures measured are low. Lately, when the aliment was evolved, the surface temperatures increased significantly, as illustrated in Fig. 7 and 8.

4. CONCLUSIONS

Comparing the analytical and practical results, it was observed that the power needed to compensate the heat loss of the aliment to the environment is much lower than apparent nominal power used in the experience. Thus, changes could be made in order to avoid the oversizing of the system, reducing power until the moment when the heat transferred to aliment is equal to the heat dissipated by the environment. In addition, a few parameters were despised, for example, contact between materials and losses.

Furthermore, simulating a real situation with the evolvement of the aliment, the temperatures in the bottom of the plate were greater than the initial surface temperature, what may cause discomfort to the user. Therefore, a smaller temperature could be established to the aliment surface in order to become it more comfortable to the client through power reduction by the resizing of the equipment electronic system.

Finally, the plate borders indicated temperatures close to 30ºC, in other words, there would be no burns if the system work with similar temperatures, enabling the production of it in near future.

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6. RESPONSIBILITY NOTICE

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