

## ENCIT-2018-XXXX

### Boiling comparative analysis in metallic container and vitreous container.

**Levy Galas Jacob**

**Edson Augusto Soares Lopes**

Universidade de Fortaleza, Núcleo de Tecnologia da Combustão, Avenida Washington Soares, 1321, Edson Queiroz, 60.811-905, Fortaleza-CE, Brasil.

levygjacob@gmail.com; edsonaslopes@gmail.com

**João Batista Furlan Duarte**

**Matheus Andreazza Araújo Leite**

**Claudio Matheus Silva Lobato Ferreira**

**Ricardo Gomes Félix Júnior**

Universidade de Fortaleza, Núcleo de Tecnologia da Combustão, Avenida Washington Soares, 1321, Edson Queiroz, 60.811-905, Fortaleza-CE, Brasil.

furlan@unifor.br; matheusandreazza@gmail.com; rfelixjr900@edu.unifor.br; claudiomatheus@gmail.com

**Abstract.** *The purpose of this paper is to detail and compare the boiling process, highlighting how it is affected by the material in which the boiling occurs and reinforce that the water does not boil only at 100°C as largely believed by the general population. The tests were performed using an iron pan coated with Teflon, a 1L capacity beaker, a six-burners Samoa Esmaltec cooker, a Minipa ET-2082C multimeter and a copper-constantan thermocouple wire. All the tests were made in the same burner of the stove, with an average power of 1.45 kW; the analysis shows that the fluid reached 101.666 °C in 25 minutes when boiled in glass and 96.666 °C in 12 minutes when boiled in a metallic container. Also, because of the Teflon coating when boiled using the metallic vessel, there were higher amounts of bubbles formation and a higher loss of liquid volume at the end of the boiling.*

**Keywords:** Boiling Point, Boiling Comparison, Glass, Metal, Thermal Analysis

## 1. INTRODUCTION

Since our first school physics classes, one concept that is first exposed to us is the boiling point of water. It is used as reference when studying chemistry, temperature scales (100 °C, 373 K, 80 °R etc.), thermodynamics, among others. It is assumed by people in general that the boiling temperature only varies by varying the pressure at which the liquid is present.

Empirically, it is known that several factors influence the boiling process of the water, such as the concentration of salts dissolved in the fluid, heating source, altitude and atmospheric pressure in which the liquid is located, the aeration level of the fluid and the material of the container in the boiling is occurring. (Marcet, 1842)

In the nineteenth century, Louis Joseph Gay-Lussac conducted experiments where he analyzed the differences in temperature of boiling water in containers of different materials. In the experiment, he concluded that the boiling is directly related to the intermolecular forces between the fluid and the vessel wall to which the fluid was allocated, among other factors. Like Louis Joseph Gay-Lussac, other scientists also dedicated their lives to the study of boiling, such as Jean-André de Luc, who studied the relationship between the degree of aeration of the water and the boiling temperature (Chang, 2004). In this paper, an each-minute data comparison of boiling in different containers is presented.

## 2. TEST METHOD

For the experiments, an iron pan coated with Teflon, a 1L capacity beaker, a six-burner Samoa Esmaltec cooker, a Minipa ET-2082C multimeter, a copper-constantan thermocouple wire.

All the tests were performed in the same burner of the stove, with a power of 1.45 kW (NBR 13932, 1997); 1L of water was measured in and transferred to the boiling vessel; the thermocouple was positioned in the center of the liquid volume and connected to the multimeter for temperature measurement. Temperatures were recorded every minute up to two measurements after temperature stabilization. After cooling the water was measured its remaining volume. Three tests were done on each container and the averages of all boiling process variables were listed in a spreadsheet in Excel. After the data were recorded, the analysis of these data was performed, the temperature averages were calculated and a comparative graph was elaborated.



Figure 1 - boil test in metallic container  
Source: The Author



Figure 2 – water boiling in a vitreous vessel  
Source: The Author



#### 4. ACKNOWLEDGEMENTS

Because it has a boiling point dependent, among other factors, of the material of the container in which it is, we can thus justify different materials for different uses of water, or solution of this. For example, the use of glass or ceramic wall reactors is more usual for the pharmaceutical industry, because the use of this material is more precise control of the temperature of the mixture over time and greater control of the process is obtained, as seen that the temperature variation is more uniform. In a metal container boiling is faster, but a lower temperature is reached. One should also bear in mind the influence of the Teflon coating applied in, for example, cookware. Teflon is a highly water-repellent substance, coating the metal container therewith causes less intermolecular forces between the liquid and the vessel wall, thereby lowering the boiling temperature, increasing the amount of bubbles, and more evaporation occurs from water. (Harper, et al., 2003)

#### 5. CONCLUSIONS

As noted in previous topics, the containers of different materials used in this experiment influence the boiling point of water, such as polytetrafluoroethylene, popularly known as Teflon. Polytetrafluoroethylene is a polymer that provides a water-repellent layer on the surface of the vessel containing the boiling fluid, directly influencing the temperature thereof, causing it to occur at approximately 96.67°C. Unlike the glass vessel, which does not have this property, it causes the full boiling temperature of the fluid to be approximately 101.66 ° C. Another determining factor in the boiling process is the amount of gases dissolved in this: the lower the gas concentration, the higher the boiling temperature. In addition, water-cooling is slower in the vitreous vessel, which explains, for example, the use of jacketed glass reactor is widely used, especially in the food, chemical, pharmaceutical and other industries. This reactor offers a number of advantages to the industrial process. It can, for example, produce stationary heat, making its operation safer and more homogeneous.

#### 6. REFERENCES

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