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# EXPERIMENTAL ANALYSIS OF A BIPHASIC CIRCUIT WITH PUMPING EFFECTS BY CAPILLARITY USING TWO EVAPORATORS IN PARALLEL

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**Abstract.** *The biphasic pumping circuits by capillarity effects (BFDPT) are passive heat transfer systems, widely used in the aerospace industry (thermal satellite control). Unlike classical cooling circuits, the fluid of a BFDPT does not circulate in the circuit due to a pump, but through the capillarity forces created in the porous medium of the evaporator that put the fluid in motion, transforming it in a totally autonomous and passive system. In addition, the fluid exchanges phase between the hot source (evaporator) and the cold source (condenser). This phenomenon considerably increases the heat transfer capacity of biphasic circuits in relation to classical cooling. Biphasic circuit work have been and is still conducted in laboratories, including parallel evaporators and parallel condensers to the system to adapt or improve the thermal control capability of the system in focus.*

**Keywords:** *space industry, capillarity forces, evaporator and condenser.*

## 1. INTRODUCTION

The rapid development of power electronics reveals an increase in the need for more advanced knowledge in terms of thermal control. Many industrial products such as electronic products (cellphones, computers, automotive sound power, etc.), general cars, motorcycles, airplanes, ships, high speed trains or even in the space (thermal regulation of a satellite) heat up and require cooling systems. It is known that conventional refrigeration technologies have reached their limits, and, therefore, there is an intense need to study alternative sources for temperature control (FAGHRI, 1995), (LACHAS-SAGNE, 2012) and (ZOHURI, 2016).

There are two main types of biphasic circuits that uses capillarity pumping: Capillary Pumped Loop (CPL), discovered in the United States in the late 1960s, and Loop Heat Pipe (LHP) which were discovered in the Soviet Union in the early 1970s. The basic difference between CPLs and LHPs is the position of the reservoir in the cycle, where in the CPL the reservoir is coupled to the circuit separated from the evaporator, and, in LHP, the reservoir is coupled to the evaporator, as can be seen in Fig. 1. These thermal control circuits are one of the most competitive solutions among the new refrigeration devices currently developed. These devices are capable of transferring large quantities of heat over long distances thanks to the circulation of the fluid by the capillarity effect and the phase transformations of the fluid (KEW, 2006) and (BERTIN, 2012).

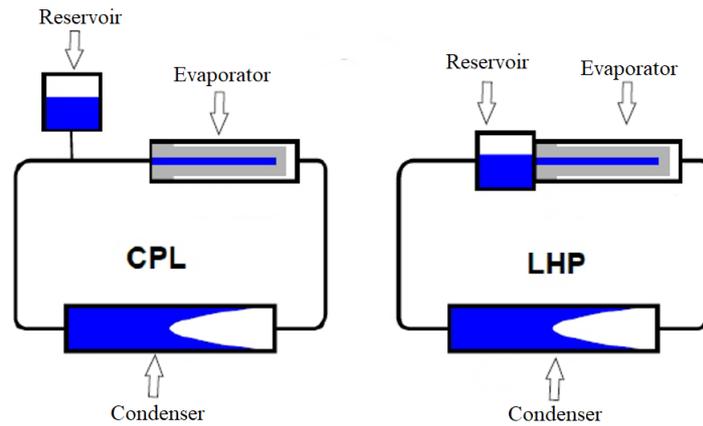


Figure 1. CPL and LHP

## 2. EXPERIMENTAL PROCEDURE

The experimental bench model analyzed and the fundamental equipment for operation such as Coriolis flow meters, pressure sensors, thermostat, PT100 probes, central Cryostat, CompactRIO, physical security equipment, reservoir, evaporator and power feeders BERTIN(2014), are shown Fig. 2.

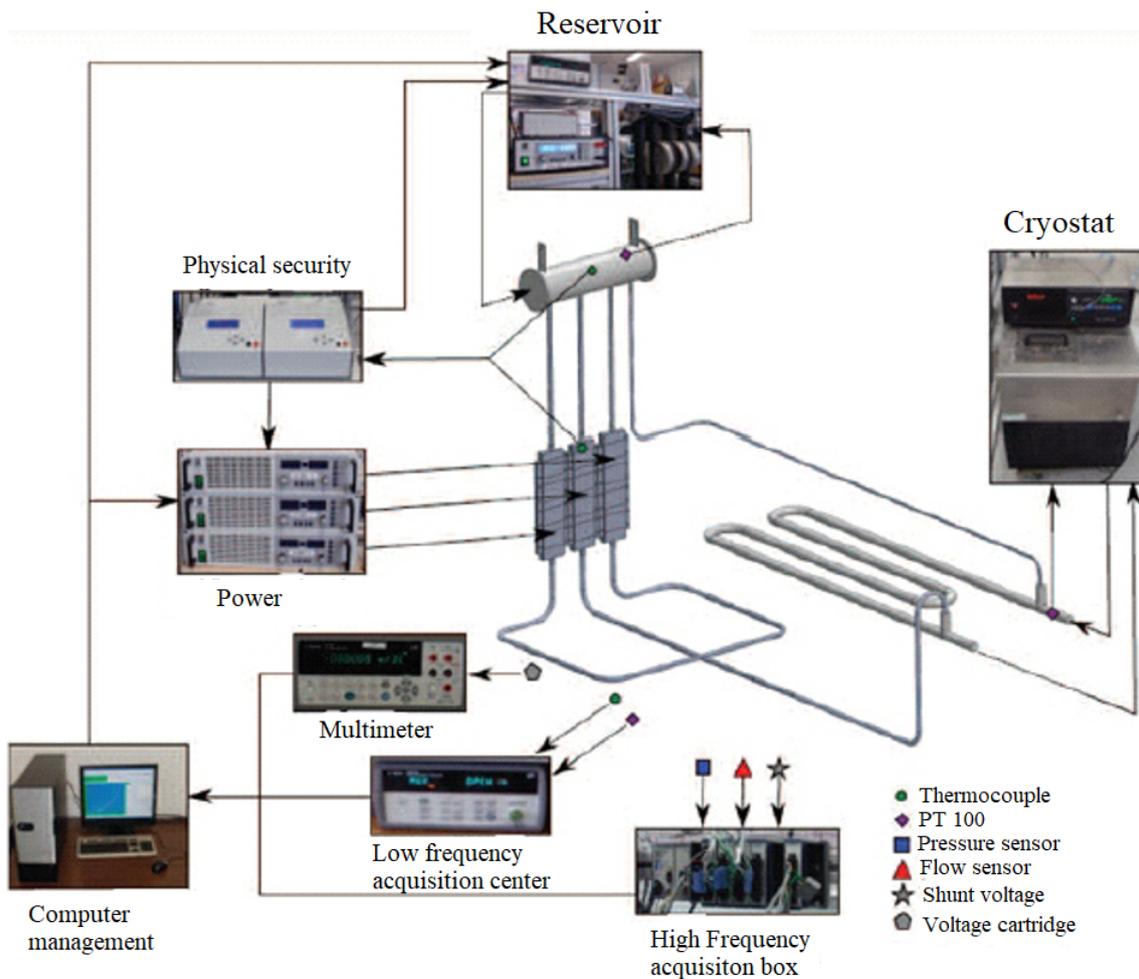


Figure 2. Equipment for data analysis.

For manipulation of the experimental bench, the LabVIEW program interface was used, and data processing was made with Excel Visual Basic. The experimental workbench was instrumented with thermocouples and pressure gauges PT100 probes, as shown in Fig. 3.

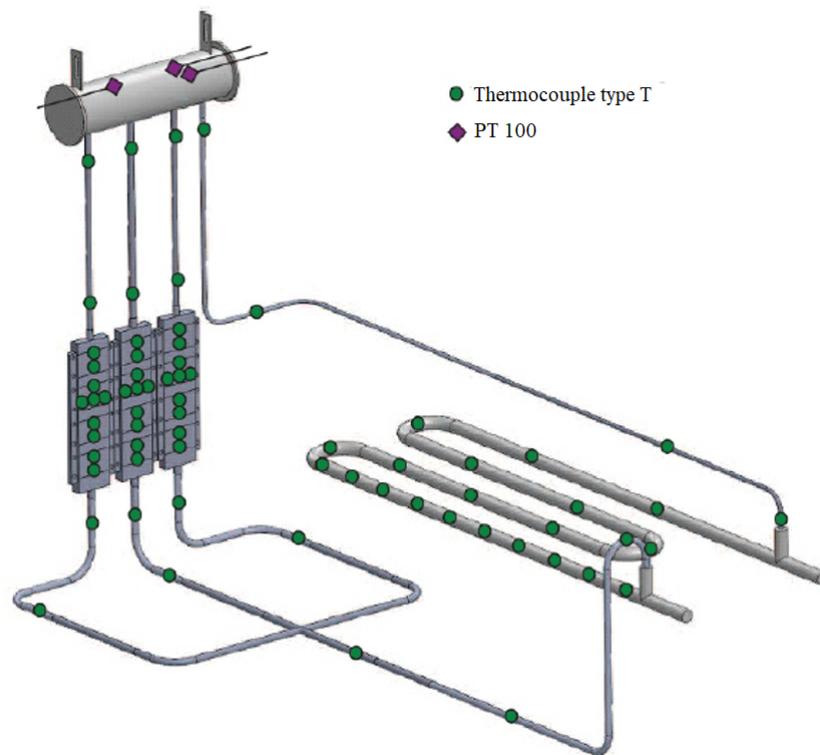


Figure 3. Positioning of the thermocouples.

The temperatures provided by the coupled thermocouples in the evaporator are presented in Fig. 4. It is understood that, for the fluid start circulating in the circuit, it is necessary that a peak of super heating occurs to create the first bubbles of vapor, as can be seen in the figure below, in the beginning of the experiment. Thereafter, the temperature in the evaporator is regulated by the internal saturation temperature of the reservoir and increased slightly with the increase in the power which is supplied to the system. The temperature at the outlet of the evaporator is practically constant, which corresponds to the temperature imposed by the reservoir.

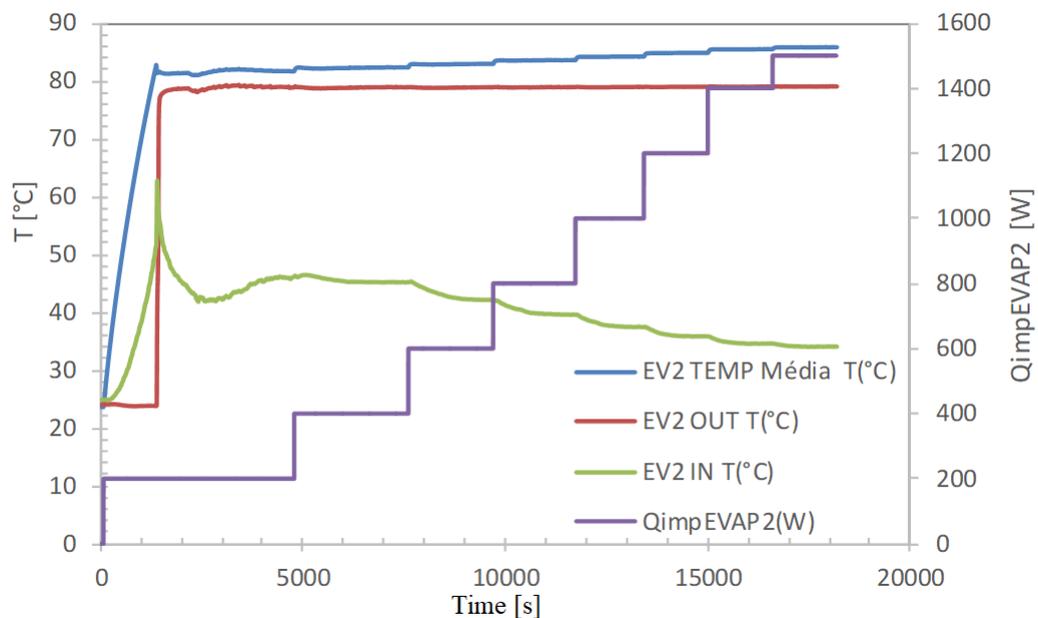


Figure 4. Temperature variation in the evaporator

Figure 5 shows the ability of the condenser - 500 cm in length - to condense the fluid in the maximum dimension. It would be appreciated that with increasing power of the source, the condenser has a greater difficulty in reducing the temperature of the fluid to the desired temperature of 20 °C . For the test at 200 W, the fluid reduces its temperature in

less than 20 cm inside the condenser. At 1,500 W the fluid reaches the desired temperature for a length of less than 100 cm, these interpretations can be seen in the figure below.

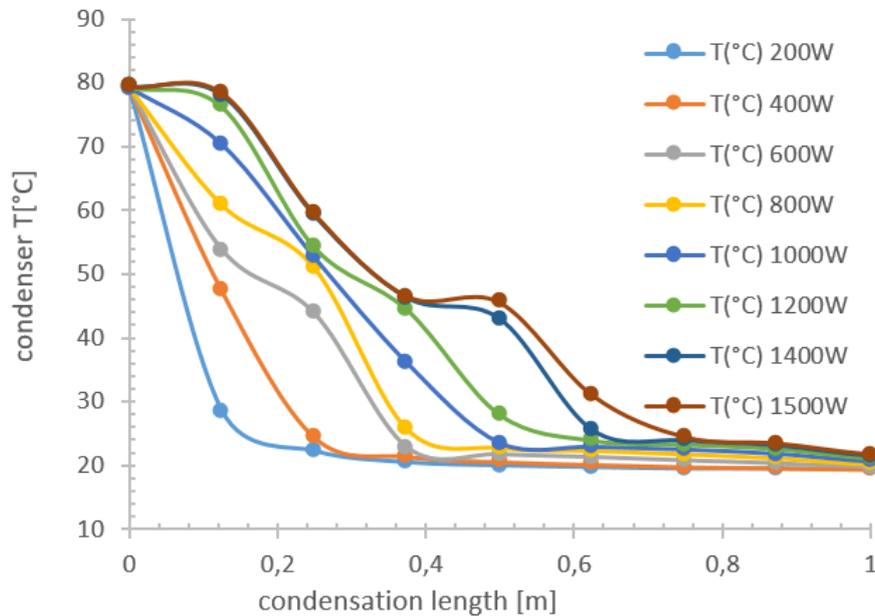


Figure 5. Temperature variation in the condenser

### 3. CONCLUSION

The studies of two-phase systems are important for understanding the critical points of this circuit (evaporator and its porous medium, condenser and the reservoir), because with a variation of one of the parameters can significantly vary the parameters in other points of the circuit. In addition, it is possible to realize the enormous potential that these systems have, capable of transferring heat over long distances. However, this study is limited because those heat transfer systems are very expensive in terms of equipment (evaporator with its porous medium, data acquisition systems, etc.). The advantage is that is only necessary to keep the temperature constant in the reservoir, since the system is totally self-regulated. Finally, it is known that numerous studies are necessary for the development of this type of heat transfer system to be able to explain in details certain phenomena that occur biphasic circuits.

### 4. ACKNOWLEDGEMENTS

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