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UTILIZATION OF THERMAL POWER OF AIR CONDITIONERS FOR WATER HEATING

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Abstract. *The electric energy, main form of water heating, is under unfavorable production conditions. Due to this problem, thought up an alternative source for water heating by use of thermal energy rejected by the conditioners air apparatus. With the objective of evaluate the energetic potential the condenser were done practical studies in a tube and tube heat exchanger, replacing the tube-flap heat exchanger of window conditioned air with capacity 18,000Btu/h. The tube and tube was connected the a water reservoir. For the realization of the thermodynamics calculations was utilized the demand of water hot raised in the Instituto Federal de Educação, Ciência e Tecnologia da Bahia – Campus Salvador. Thus, for a average flow of 1,040L/h there was obtained a maximum temperature of 80.6°C, which can be considered positive and to conclude that the air conditioners have energy potential to heat water whose applications require moderate temperatures. Furthermore, the cost analysis proved up satisfactory since the only required investment is the initial to equipment adaptation. However there is need for an auxiliary system, thermally insulated, for storage of the final product which increases the initial cost of the process.*

Keywords: *Water heating, air conditioners, Rejected heat, Thermal Energy Harnessing*

1. INTRODUCTION

It is known that water heating lot of electricity demand, since most of the time this is done through the use of electric heaters. Alternative sources such as solar and gas heating are being used, but they have their limitations.

Generally, alternative sources have, for safety reasons, electrical energy as an auxiliary source. The problem of the use of electricity is the high cost and, more recently, low reservoir levels at hydroelectric, beside worry, are causing the cost becomes even higher.

The IFBA - Campus Salvador it was found the need of hot water consumption. However, with the increase in the number of courses and the consequent increase in the number of classes, the consumption of electricity has grown significantly, which has managers worried. So to balance this balance, consumption x need, it was decided to analyze the feasibility of using the heat rejected by the air conditioning units for heating water.

Therefore, this study aims to assess the energy potential in the refrigeration condenser for water heating. Thus, to obtain a final product of lower cost by adapting existing air conditioners, as well as serve as a basis for future research.

2. THEORETICAL BASIS

The water heating is the temperature rise thereof. This form of use is from the comfort of bathing until hygiene issues such as hospital laundries, helping in the removal of dirt and elimination of bacterial load. Given the various heating purposes of water is required prior to installation of a heating station, to survey the local need to establish the working temperature range.

2.1 The Importance of Water Heating

It is known that the water heating requires a large amount of power, either electric, solar, or even provided a combustion gas. According to Habits Possession Research (2012, *apud* SOUZA *et al*., 2007), about 80.9% of Brazilian households heat water in any way for bathing and other purposes.

Of the alternative sources of energy has the gas and solar responsible for 5.9% and 0.4%, respectively. However, according to Greening and Azapagic (2014) the use of natural gas to generate heat causes a high environmental impact.

Electricity accounts for 73.5% of this warming according to Eletrobras Procel (2012, *apud* SOUZA *et al.*, 2007). The electric shower is the most used for this purpose with a portion of 99.6% (Souza *et al*., 2007). Therefore, the electric power, which is considered a form of noble energy, has suffered a series of significant increases to the detriment of their unfavorable production conditions.

2.2 System Refrigeration by Vapor Compression.

The refrigeration cycle by Vapor Compression (RCV) is composed of four basic components: compressor, condenser, expansion device and evaporator.

The condenser is a heat exchanger whose purpose is to reject heat from refrigerant system, cooling the refrigerant fluid causing the same change in thermodynamic state, of superheated vapor to compressed liquid. According Yumrutaş *et al.* (2002), in the transformation is unavoidable some pressure drop in the system.

These devices can be classified according to the fluid cools which can be air or water, and for the constructive type. The heat exchanger of type tube and tube, are constituted generally by two circular section pipes, concentric with different diameters. Inside of the inner tube passes a fluid called fluid tubular. In the space between the outer pipe and the inner pipe passes the other fluid, referred to as annulus fluid. Heat exchange occurs between the fluid in the inner pipe interface due to the temperature difference (BARALDI, 2011).

The rejected heat (Qh) by the condenser is determined by the First Law of Thermodynamics which can be expressed as Eq. (1).

$$\dot{Q} + \dot{m} \times he = \dot{W} + \dot{m} \times hs \qquad (1)$$

3. METHODOLOGY

As the objective is to heat water the heat exchanger used it was the tube in tube and annulus fluid water and tubular fluid R-22.

A survey of the need for hot water in all sectors of the Instituto Federal de Educação Ciência e Tecnologia da Bahia - IFBA, Campus Salvador was made through spreadsheets and interviews with officials responsible for the respective sectors. From the information gathered it was found that the greatest demand is for the bath, thus the determining the flow required for the tests was based on this application.

For the determination energetic availability of conditioned air was required analyse the technique specification of the compressor of the equipment utilized this work.

After compressor study, were installed in the input and in the output of condenser, pressure gauge and two channels of a penta thermometer. Others two channel of the thermometer were installed in the water reservoir, in the input and in the output, and other inside in the reservoir.

The water reservoir has capacity 20L, thermally insulated, equipped with water pump for circulation, according Fig 1.

Those information was collected during 267 minutes, with intervals of five minutes in the first four measurements.

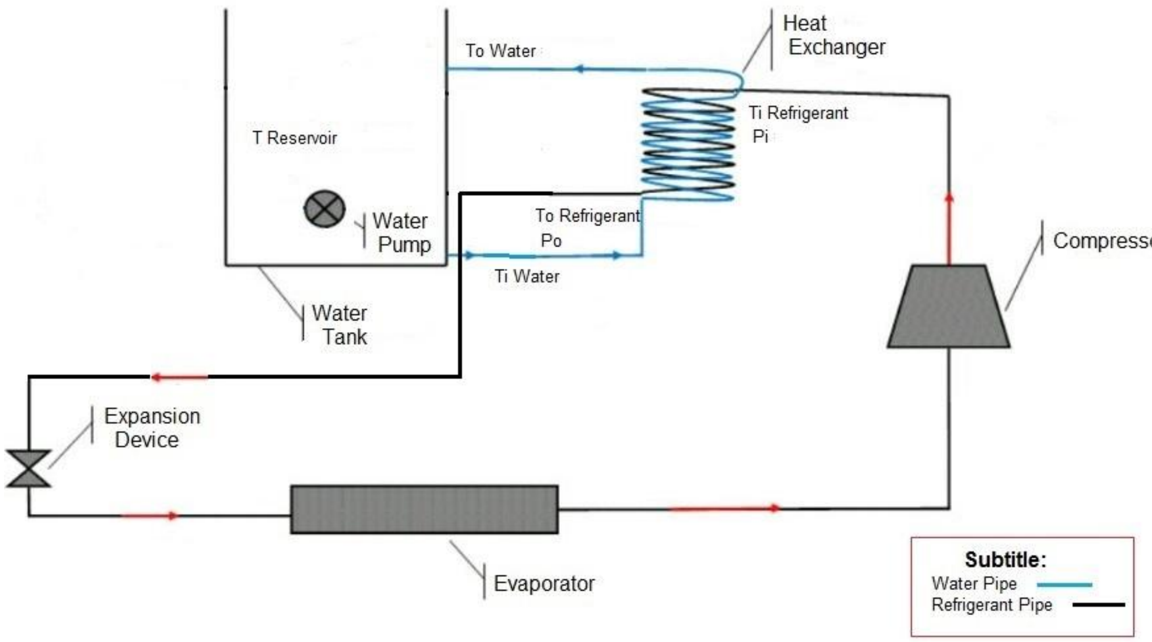

Figure 1 – Final Mounting of the Equipament

4. RESULTS AND DISCUSSION

After lifting the hot water demand in the institution it was found that 28 of the 53 sectors require hot water, and its major use for bathing, as Fig 2.

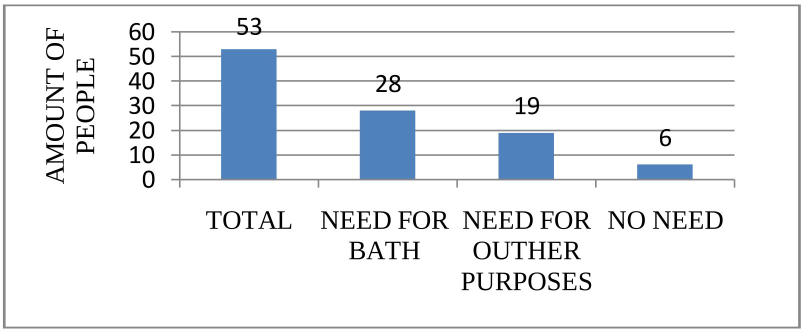

Figure 2 – Hot Water Demand Survey of Campus Salvador

To determine the required flow calculation, the estimated time was 5min with a shower 4L / min. Thus it was determined consumption twenty liters of water for bath. In twenty working days per month, 200 students were estimated bathing in the gym and 5 employees per department who needs hot water demand, so if have 335 people a day taking a shower, according to what is in Tab. 1

Table 1 – Monthly Hot Water Consumption – Campus Salvador

Gym (L/day)	Departaments (L/day)	Total (L/day)	Total (L/month)
4,000	2,700	6,700	134,000

Thus, were obtained the data needed to determine the energy availability in the condenser were obtained , complemented with information of compressor.

Table 2 – Mean Values and Standard Deviation of Pressure and Temperature of Refrigerant Fluid

	Pressure (Psi)	Temperature (°C)
Input	370.8Psi ± 18.4Psi	102.1°C ± 9.1 °C
Output	368.9Psi ± 19.2Psi	42.8°C ± 0.7°C

With the pressure and temperature values of the input and output, shown in Table 2, was determined enthalpy values of refrigerants in order to calculate the amount of heat rejected by the condenser according to Eq (1). The mass flow was determined by relationship ratio of the volumetric rate found in the technical specifications of the compressor and the specific volume of incoming refrigerant. The calculated heat flow was approximately 38.79 kW as Eq. (2) and Eq. (3)

$$\dot{Q} = 0{,}18868467\,\frac{kg}{s} \times \left(98{,}56\,\frac{kJ}{kg} - 304{,}161278\,\frac{kJ}{kg}\right) \tag{2}$$

$$\dot{Q} = -38{,}79KW \tag{3}$$

With the mass flow was possible determined to scale the pump to be installed in the system.

After the viability of energy availability, equipment adapted according to the methodology whose temperature values versus time can be seen in Fig 3.

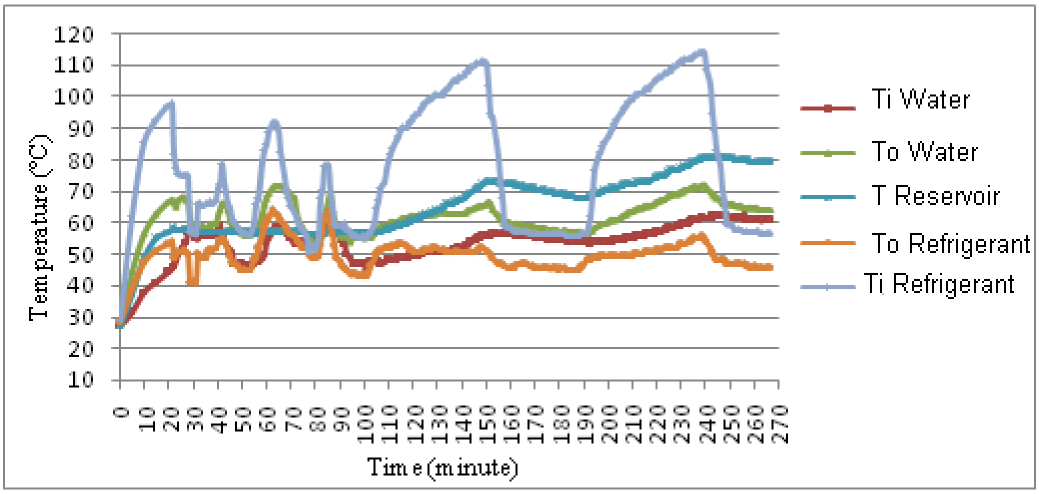

Figure 3 – Temperature Versus Time Graph

Analyzing at Figure 3 we can observe the behavior oscillations in the inlet and outlet temperatures of the water and the refrigerant, especially in the initial hundred minutes, where the system had not entered into a uniform regime . The temperature of the reservoir had a behavior almost constant between 10min and 110min, however it began to rise following the growth of the refrigerant inlet temperature, which from 100min displayed a seasonal pattern characterized by high temperature peaks.

The compressor has a security device called pressure switch. This device turn off the compressor when the system pressure reaches high levels.

After a certain working time water reached thermal equilibrium with the refrigerant thereby proper temperature sub-cooling of the fluid was not being reached, causing the high pressure of system reached more than 400 Psi in according to the pressure gauge. Thus, the compressor was turned off by the pressure switch and religated, by same, when the pressure was reduced. This caused a large fluctuation in the refrigerant temperature.

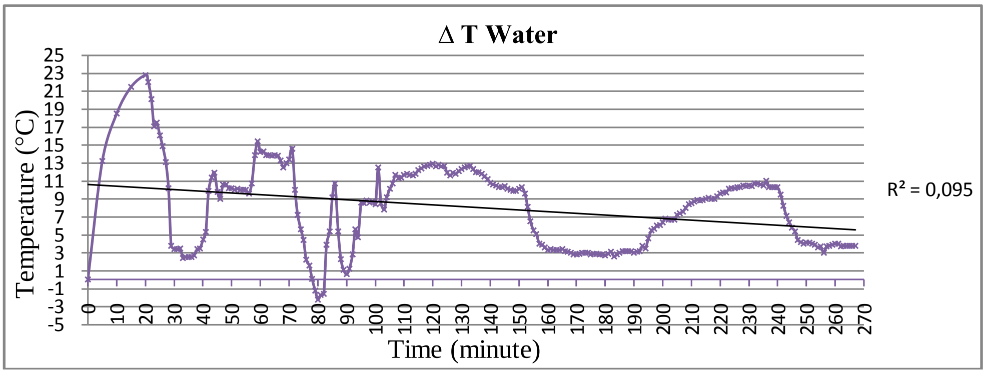

Figure 4 – Variation of Water Temperature

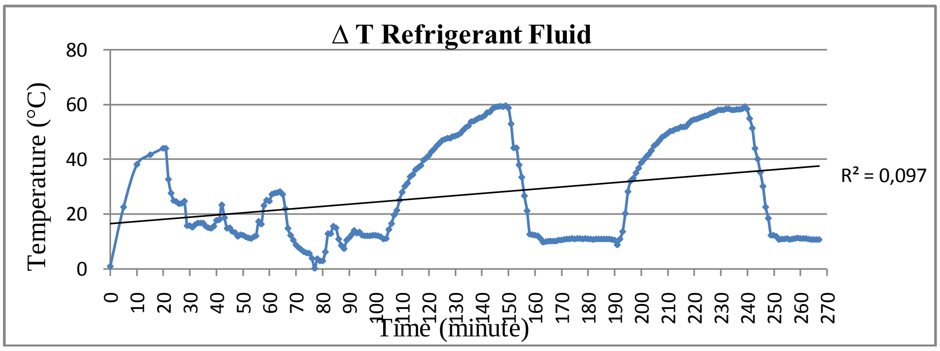

Figure 5 – Variation of Refrigerante Fluid Temperature

Observing the Fig 4 and Fig 5, it was noted that at approximately eighty minutes of operation Water Te was higher than Ts water and the refrigerant temperature variation tended to zero. This occurred because the compressor disarmed and as the hot water circulation circuit is independent of the operation of the air conditioner, the tank water continued circulating. As the reservoir is thermally insulated, the temperature of the reservoir remains, however, the water entered the condenser as determined temperature and had no refrigerant traversing the system, it has lost heat to the pipes of the heat exchanger thus its temperature was reduced.

Since the temperature of the water inside the tank rises without fluctuation, as can be seen in Figure 7, since the reservoir is thermally isolated, the temperature of the water in the reservoir is maintained when the compressor trips equipment, since the heat loss to the environment is small.

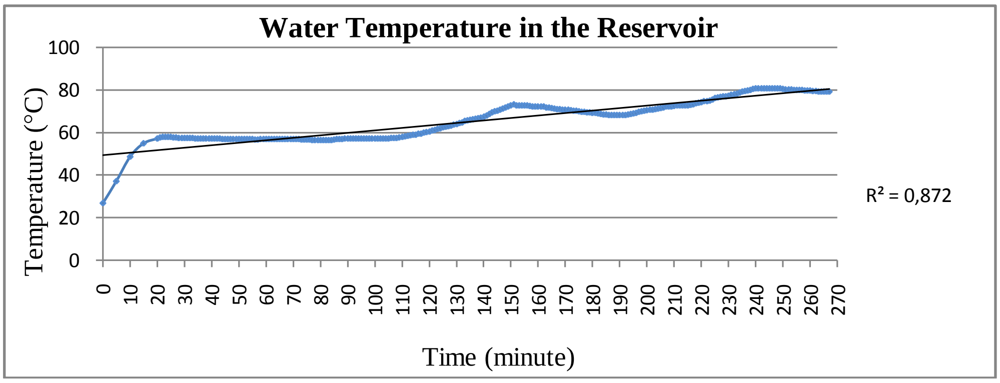

Figure 7 – Water Temperature in the Reservoir

After the machine has been put into operation it was established that lasted 8 minutes to heat the water container, whose volume is 20L, to 45 ° C. Soon, there have been a flow rate of 2.5 liters of hot water per minute.

4. CONCLUSION AND SUGGESTIONS

With the results it is concluded that it is possible to heat water from the heat rejected by the condenser of air conditioner window type.

Despite the adjustments necessary for the utilization of this energy, which today is wasted, its use is still viable, especially when compared with the usual forms of heating water that has high maintenance costs while the cost of this model is only early.

Even with positive results the model can be improved through the bypass system being actuated by solenoids. Moreover, as the water outlet temperature is a function of flow rate and energetic availability of the apparatus can be tested with other configurations such as different flow rates, other models of equipment and other refrigerants fluids..

5. REFERENCES

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