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Improvement of recovery energy in the absorption heat transformer process using water - Carrol ™ for steam generation

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In this work, the heat transformer absorption cycle is operated with the Water – Carrol™ mixture. The water is the working fluid and Carrol ™ is the absorber solution. In the absorption cycle, alternative energy is added in the generator for steam generation and part is added in the high pressure evaporator component. Recovery energy is revalued in the absorber. The water - Carrol™ mixture has a higher solubility than aqueous lithium bromide mixture. For this reason the coefficient of performance is higher and the crystallization risk is lower. The improvement of the total amount of energy recovery in the industrial process using water - Carrol ™ is shown. The best conditions for the energy recovery are based on the Energy index; this is the ratio of enthalpy coefficient of performance between the Carnot COP. The experimental test device had shown an upgrade from 78.0 °C to 128.3 °C. The mean COP was evaluated for an energy recover of 28 % from alternative energy.

1. Introduction

It is a fact that each year the energy consumption is higher; however the oil, which is the main energy source, is coming to an end. Many of the equipments that are able to use alternative energy (solar, geothermal, etc.) have low performance, and in order to improve it, it is necessary a better understanding of the mechanisms of heat transfer. Absorption Heat Transformers (AHT) are equipments able to use alternative energy, even the waste thermal energy from an industrial process can be used (Ma et al., 2003). In this paper the improvement of the performance of an absorption heat transformer is shown.

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2. Absorption heat transformer

An AHT have five main components: steam generator, absorber, condenser, economizer and evaporator. A working mixture is used for the absorption process, in this case Water – Carrol ™ (lithium bromide + ethylene glycol) was selected. This mixture has a higher solubility than water - lithium bromide (which is one of the most common mixtures used in AHT). For this reason the efficiency is higher and the crystallization risk is lower at high concentrations. Figure 1 shows a schematic diagram of the system, in a plot pressure against temperature. Alternative energy is supplied an intermediate temperature to the generator and the evaporator (T_{GE}, T_{EV}), in the generator is carried out the separation of a part of the working fluid (water) from the absorbent. The working fluid is condensed in the condenser delivering an amount of heat at low temperature (T_{CO}). Then the working fluid goes to the evaporator through the expansion valve (reducing its pressure) where it is evaporated at the same temperature that the generator. The vapor working fluid goes to the absorber where it is absorbed by the mixture coming from the generator delivering heat at high temperature (T_{AB}). Finally the mixture goes to the generator starting the cycle again. Between the absorber and the generator, a heat exchanger is placed (economizer). Its function is to preheat the mixture coming from the generator.

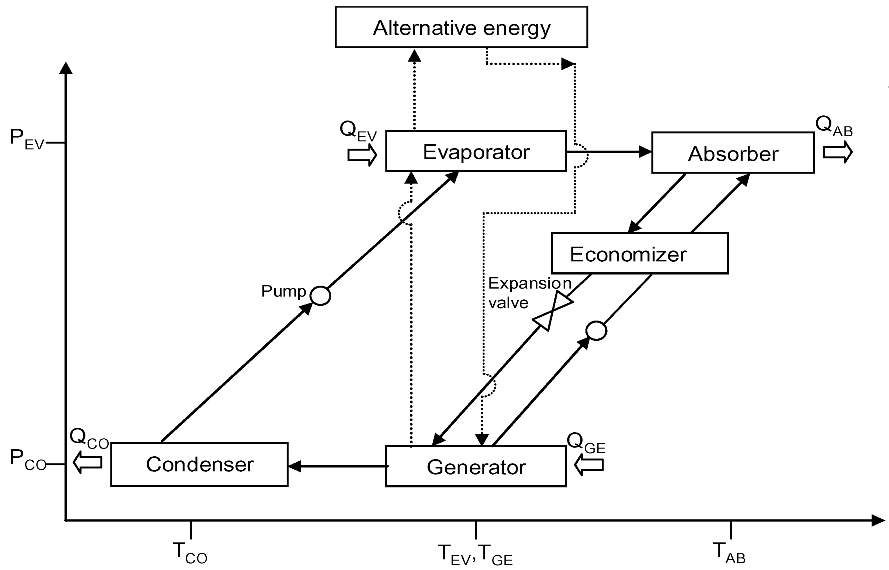

Figure 1. Schematic diagram of an absorption heat transformer

Two important parameters in AHT are: coefficient of performance (COP) and gross temperature lift (GTL). The COP is the ratio of heat obtained in the absorber and the heat supplied to the generator and evaporator:

$$COP = \frac{Q_{AB}}{Q_{GE} + Q_{EV}} \quad (1)$$

The GTL is the difference between the temperature obtained in the absorber and the temperature of the alternative energy applied in the evaporator:

$$GTL = T_{AB} - T_{EV} \quad (2)$$

3. Experimental Set – Up

In the Applied Thermal Engineering Laboratory in the Autonomous University in Morelos, México, there is an Absorption Heat Transformer. The five main components of this equipment are plate heat exchangers (PHE), as far as we know, there are no previous works in AHT of this kind. This type of heat exchangers has many advantages such as: being compact, flexible and higher heat transfer (Kumar Dwivedi and Kumar Sans, 2007) which brings high performance to the system. The PHE were provided by the company Sondex, made in stainless steel 316 and thermal capacity of 1000 W. The configuration of the two streams is countercurrent. The alternative energy applied to the generator and evaporator is simulated by electrical resistances, which are used to heat water. The cool stream used in the condenser, is supplied by a cooling tower, that water has temperature between 17 – 20 °C. The useful heat obtained in the absorber is removed by a stream of ethylene glycol. All the temperatures are monitored by thermocouples type “T”, for reading this thermocouples a program in HP Vee software was made, figure 2 shows an image of the data acquisition program. Experimental data has being obtained in this equipment; so far, it is possible to achieve steady state with a simulated alternative energy of 80 °C. In previous works with the mixture water - Carrol ™ (Romero, 2001), has been demonstrate that is possible to obtain useful heat in the absorber at 128°C. Also it has been demonstrated that the GTL is higher by 10 °C for this mixture in comparison to the water - lithium bromide mixture (Rivera et al., 1999). The figure 3 shows the improvement of the energy recovery for both mixtures.

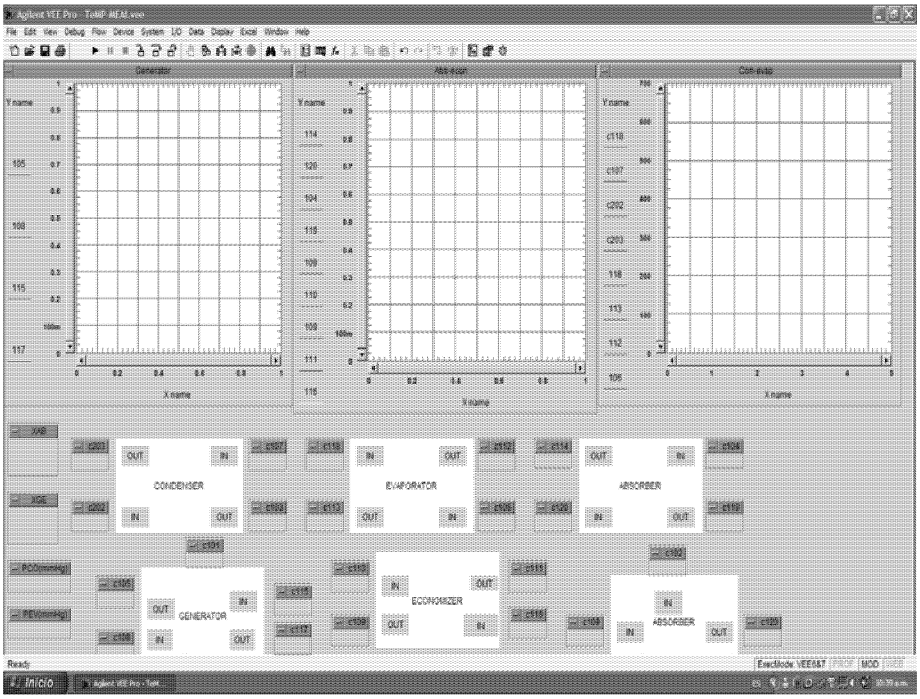

Figure 2. Data acquisition program.

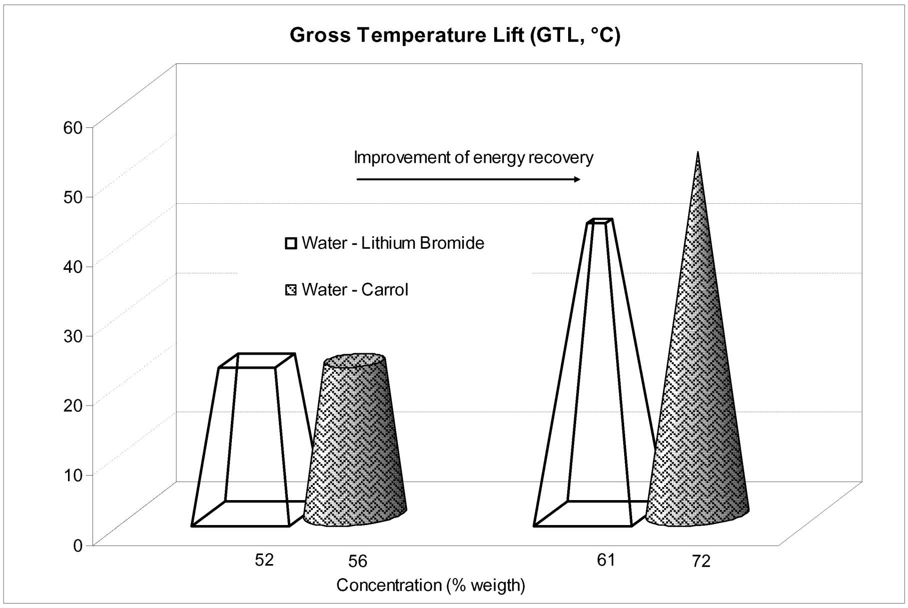

Figure 3. Improvement of energy recovery for water - lithium bromide and water - Carrol ™.

4. Steam Generator

The steam generator is one of the main components in the AHT. In the generator, intermediate temperature energy is supplied, the working mixture is heated until the equilibrium temperature, water steam and a concentrated mixture (in Carrol™) is obtained. Through the deep knowledge of the heat transfer mechanism in the generator, will be possible to achieve a better performance in the AHT, and therefore, a better use of the alternative energy. For this reason thermocouples type "T" were placed in the wall of the plate heat exchanger; a program for in line determination of the heat transfer coefficients was made (figure 4).

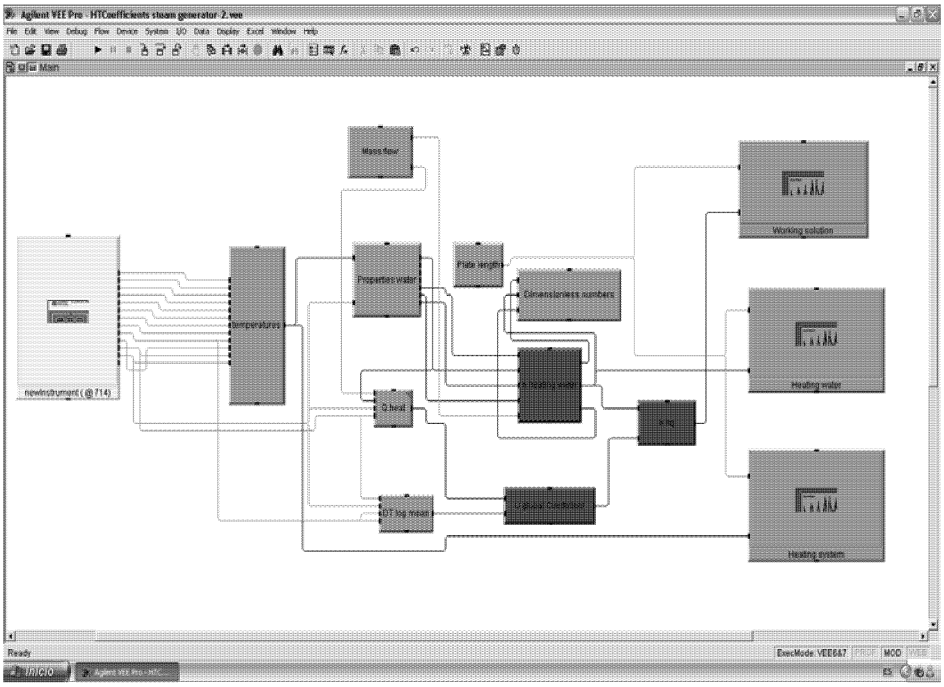

Figure 4. In – line determination of heat transfer coefficients

The program allows the in – line determination of the heat transfer coefficients for the heating water and for the working mixture water - Carrol ™.

5. Conclusion

An improvement in an absorption heat transformer has been shown. The AHT operated with the working mixture water - Carrol ™. It has been proved that this mixture shows a better performance in AHT in comparison with the water - Lithium bromide mixture, which is the most common used in these systems. The experimental set – up is composed by five plate heat exchanger, that have higher heat transfer in comparison with other kind of heat exchangers. In order to improve the utilization of the alternative energy, the steam generator has been instrumented for in – line determination of heat transfer coefficients. This allows a better understanding of the heat transfer mechanism, and, therefore a better use of the alternative energy applied to the AHT system.

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