Jiří Jaromír Klemeš, Petar Sabev Varbanov and Peng Yen Liew (Editors)
Proceedings of the 24th European Symposium on Computer Aided Process Engineering – ESCAPE 24
June 15-18, 2014, Budapest, Hungary.

Absorption cooling utilizing geothermal water: the paradigm of Morocco

A.D. Anastasiou[a], A. Barkaoui[b], Y. Zarhloule[b], M. Georgiadis[a], S.V. Paras[a], A.A. Mouza[a]*

[a] Laboratory of Chemical Process and Plant Design, Department of Chemical Engineering, Aristotle University of Thessaloniki
[b]Laboratory of Mineral Deposit, Hydrogeology & Environment, Faculty of Sciences, University Mohammed Ist, Oujda, Morocco
*mouza@auth.gr

The growing population causes augmentation of energy demands which are mainly covered by consuming fossil fuels. As a result modern societies must deal with many environmental issues, such as the greenhouse effect, the amount of toxins in the atmosphere, as well as economic issues like and the decreasing availability and consequently the increasing price of crude oil. All these have triggered the utilization of new, environmental friendly energy resources like the wind and the solar power as well as the geothermal energy.

By the term geothermal energy we define the energy derived from the heat in the interior of the earth. The most common criterion for classifying geothermal resources is based on the heat content of the geothermal fluids that act as the carrier which transports heat from the deep hot rocks to the surface. Depending on their heat content, geothermal fluids are usually categorized as low (<125°C), intermediate (125-225°C) and high enthalpy (>225°C) geothermal resources (e.g. Hochstein, 1990). The most important use of high enthalpy fluids is for electricity production, while, due to their low quality heat content, low enthalpy resources can be used only in direct applications, e.g. swimming pool or greenhouse heating, providing hot water for domestic use or drying of agricultural products. Another promising application of low enthalpy geothermal fluids is for cooling agricultural products as well as for air conditioning. In this case the absorption refrigeration systems use a low enthalpy geothermal (temperature 80-120°C) as heat source. A relevant work has been published by He & Anderson (2012) who have proposed the use of geothermal water for providing heating and cooling to buildings belonging to the University of West Virginia.

In the absorption systems, a secondary fluid or absorbent (i.e. *LiBr*) is used in order to create a pressure gradient for circulating the refrigerant (water). As presented in ***Fig. 1,*** a single stage refrigeration system consists basically of one solution pump and four heat exchangers. Working fluid from the outlet of the absorber is pumped by the solution pump to the higher pressure level. In the generator the refrigerant (water) is removed from the *LiBr* solution by absorbing heat from the geothermal water. Then the *LiBr* solution in liquid state is drained back to the absorber as absorbent, while the refrigerant in vapor phase is transferred to the condenser. The condensation is then driven through an expansion valve, which produces a low temperature refrigerant liquid that is ready to be used for chilling in the evaporator. For a given cooling demand (i.e. temperature and flow rate of the chilled fluid) a geothermal fluid flow rate can be calculated depending on the geothermal fluid temperature. In turn the cooling load and the temperature of the geothermal fluid determine the operating pressure of the unit, the amount of the utilities (mass of cooling water) and the size of the equipment. Thus both of them seem to be crucial for the economic viability of the absorption cycle.

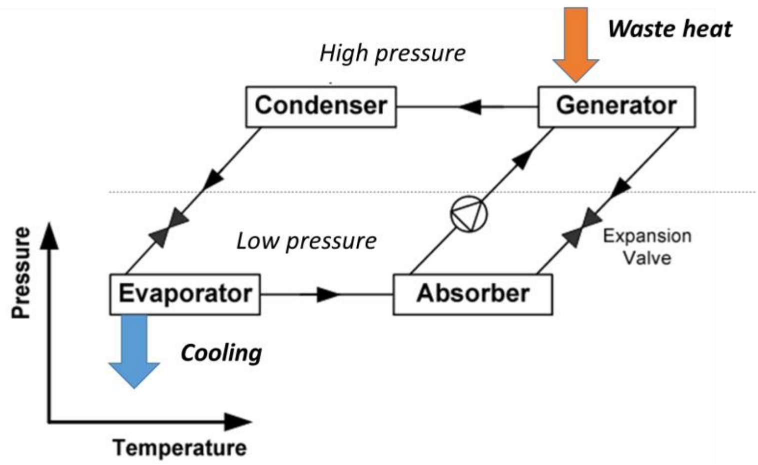

Figure 1: The main devices of an absorption chiller.

North Eastern Morocco is an area with a significant available geothermal potential, while the largest geothermal gradient is around 50°C per Km depth. According to Zarhloule (1999), the temperature and the artesian rise of most of the thermal springs in North Eastern Morocco result from groundwater circulating at depth within a framework of recent volcanic area and a system of basement faults. Considering the hot climate of the region an application that would use geothermal energy for producing cooling load would be very attractive, both from financial and environmental point of view. The aim of this study is to explore the possibility of using an absorption chiller which utilizes low enthalpy geothermal water as heat source and it is located in Northern Morocco. In order to achieve this, a sensitivity analysis is performed by varying the inlet temperature of the geothermal water and the cooling load demand. For each case the operation of the unit is simulated using a commercial process simulator (*Aspen Plus 7.0*). The simulation results (i.e. mass flow rates, heat loads, equipment sizing etc.) are transferred to a relevant cost estimator software *(Aspen Icarus)* where the cost of the equipment as well as the overall capital cost are estimated. It is known that the energy content of the geothermal fluid and the drilling cost increase with the depth of the well and that both of the above factors depend on the specific area. Thus in the present study relevant data concerning the Northern Morocco region of are used. Finally, the economic viability of each scenario will be evaluated. Work is currently in progress for producing the final results.

Acknowledgement

Financial support from the IRSES DISKNET project of FP7 (Contract No: FP7-PEOPLE-2011-IRSES-294933) is gratefully acknowledged.

References

HOCHSTEIN, M.P., 1990. Classification and assessment of geothermal resources. In: Dickson, M.H. and Fanelli, M., *eds*., *Small Geothermal Resources: A Guide to Development and Utilization*, UNITAR, New York, pp. 31—57.

HE, X. & ANDERSON, B. J. 2012. Low-Temperature Geothermal Resources for District Heating: An Energy-Economic Model of West Virginia University Case Study. *In: 37th Workshop on Geothermal Reservoir Engineering*, 2012 Stanford.

Zarhloule Y. Moroccan geothermal potentialities: Integrated Approach using deep temperatures and surface indices. *PhD Thesis*. Univ. Mohammed 1st Fac Sci Oujda, 153p. (1999). (in French)