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Experimental Analysis on waste chill recovery heat Exchanger

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Abstract- To make a waste chill recovery (WCR) heat exchanger that can be applied to any ice maker to increase its energy efficiency. The WCR device is basically a type of “shell and tube” heat exchanger that pre cools makeup water being charged to the ice maker with the help of cold waste water being discharged from the ice maker. Relatively warm makeup water flows through the tube while the near-freezing waste water flows around the tube within the shell of the heat exchanger. Heat is transferred from the makeup water to the discharge water, which lowers the temperature of the water charged to the ice maker’s reservoir.

Index terms- Chill, WCR, Heat exchanger, Waste, Reservoir

1. INTRODUCTION

Waste chill recovery (WCR) heat exchangers can be retrofit to commercial-size automatic ice makers to improve the energy efficiency and capacity of the ice maker. Commercial ice cube makers produce ice via a batch process. This ice-making process concentrates any impurities in the residual water, leaving the cube relatively pure and clear. Thus, some portion of the water charged to an ice maker must be purged to avoid scaling within the sump or on other ice maker components and to ensure that clear cubes are produced. The purge water is often near freezing or at least considerably cooler than the makeup water.

The WCR device is a type of “shell and tube” heat exchanger that pre cools makeup water being charged to the ice maker with cold purge water being discharged from the ice maker. As a result, the amount of heat that must be removed from the water by the ice maker’s refrigeration system is reduced along with the electricity required to drive the refrigeration system. Reducing the amount of makeup water cooling also reduces the cycle time between harvests, which increase capacity.

The cost-effectiveness of a WCR heat exchanger varies considerably depending on machine specific and site-specific operating conditions. This Federal Technology Alert (FTA) presents detailed information and procedures that a Federal energy manager can use to evaluate the cost-effectiveness of potential WCR heat exchanger applications.

2. WCR TECHNOLOGY

Waste chill recovery (WCR) heat exchanger could be applied to any ice maker to improve its energy efficiency. The WCR device is basically a type of “shell and tube” heat exchanger that precools makeup water being charged to the ice maker with cold waste water being discharged from the ice maker. A simplified, generic flow diagram of the concept is shown in Figure. Relatively warm makeup water flows through the tube while the near-freezing waste water flows around the tube within the shell of the heat exchanger. Heat is transferred from the makeup water to the discharge water, which lowers the temperature of the water charged to the ice maker’s reservoir. As a result, the amount of heat that must be removed from the water by the ice maker’s refrigeration system is reduced along with the electricity required to drive the refrigeration system.

The effectiveness of the heat exchanger (i.e., its ability to transfer heat from the makeup water to the discharge water) depends on the amount of heat transfer surface area (tubing surface area) relative to the amount of heat being transferred and the layout of tubing and flow channels within the heat exchanger shell. Increasing heat transfer surface area enhances heat exchanger effectiveness, but increases its size, weight, and cost. A “counter flow” layout that minimizes the temperature difference between the two fluid streams at any point along the tubing (imagine a smaller pipe [the tubing] within a larger pipe [the shell], with the makeup water entering the smaller pipe at one end and the discharge water entering the larger pipe at the other end) is best for heat transfer, but can result in a cumbersome or complex and costly design.

The design variations are practically endless; cutaway drawings of two WCR heat exchangers currently offered for application to commercial ice makers (machines with an ice-making capacity ranging from a few hundred to a few thousand pounds per day) are shown in Figures. WCR heat exchanger operating principles, design variations, energy-saving mechanisms, and other potential benefits are

explained. Specific procedures and equations are provided for estimating energy savings. Proper application, installation, and operation and maintenance impacts are discussed. Two hypothetical case studies are presented to illustrate the evaluation procedures and equations.
Commercial ice cube makers produce ice via a batch process. This ice-making process concentrates any impurities in the residual water, leaving the cube relatively pure and clear. Thus, some portion of the water charged to an ice maker must be purged to avoid scaling within the sump or on other ice maker components and to ensure that clear cubes are produced.
The purge water is often near freezing or at least considerably cooler than the makeup water. The WCR device is a type of “shell and tube” heat exchanger that precools makeup water being charged to the ice maker with cold purge water being discharged from the ice maker. As a result, the amount of heat that must be removed from the water by the ice maker’s refrigeration system is reduced along with the electricity required to drive the refrigeration system. Reducing the amount of makeup water cooling also reduces the cycle time between harvests, which increases capacity.

The cost-effectiveness of a WCR heat exchanger varies considerably depending on machine specific and site-specific operating conditions. This Federal Technology Alert (FTA) presents detailed information and procedures that a Federal energy manager can use to evaluate the cost-effectiveness of potential WCR heat exchanger applications. WCR heat exchanger operating principles, design variations, energy-saving mechanisms, and other potential benefits are explained. Specific procedures and equations are provided for estimating energy savings. Proper application, installation, and operation and maintenance impacts are discussed.

Two hypothetical case studies are presented to illustrate the evaluation procedures and equations. Manufacturers, users, and additional references are provided for prospective users who may have questions not fully addressed in this FTA. A description of Federal life-cycle costing procedures and a life-cycle cost summary for the Energy Conservation Investment Program are presented in the appendixes.

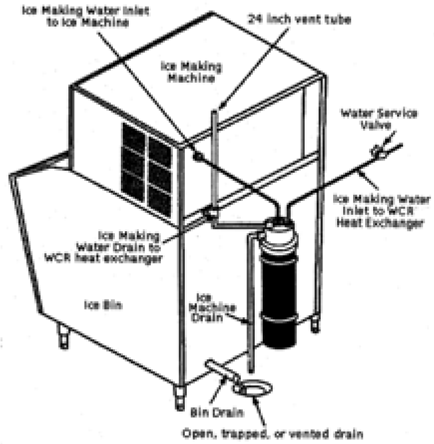


Fig 2.1 WCR basic view

3. LITERATURE REVIEW

1 In December 1990
R.Z. Wang*, J.Y. Wu, Y.X. Xu, W. Wang, have presented that A heat regenerative adsorption refrigerator using spiral plate heat exchangers as absorbers’ and an adsorption heat pump for air conditioning using plate ®n heat exchangers or plate ®n shell and tube type heat exchangers as absorbers have been developed and researched. Experimental research results are shown. The activated carbon methanol adsorption pair is used for the two kinds of adsorption systems. With a heat source temperature of 1008C, the refrigerator achieved a refrigeration power density of more than 2.6 kg ice per day per kg activated carbon with a co-efficient of performance (COP) of 0.13, and the heat pump achieved 150 W/kg activated carbon for air conditioning with a COP of about 0.4. 2 In December 1997
The U.S. Department of Energy, have presented that the WCR heat exchanger can be the Federal Technology Alert(FTA), one in a series on new technologies, describes the theory of operation, energy-saving mechanism, and field experience for the technology, and presents a detailed methodology, including example case studies, for conducting a site-specific evaluation. 3 In March 1998
R. Z. WANG*, Y. X. XU, J. Y. WU AND W. WANG, have presented A heat regenerative adsorption refrigerator
using spiral plate heat exchangers as absorbers and an adsorption heat pump for air conditioning using plate Þn heat exchangers as absorbers have been developed and researched, experimental research results are shown. The activated carbon methanol adsorption pair is used for the two adsorption systems, which yield a refrigeration power density of more than 2)6 kg ice per day per kg activated carbon and 150Wkg~1 activated carbon for air conditioning, respectively. 4. In February 2001

A.O. Dieng*, R.Z. Wang, have presented that the primary objective of this review is to provide fundamental understandings of the solar adsorption systems and to give useful guidelines regarding designs parameters of adsorbent bed reactors, and the applicability of solar adsorption both in air-conditioning and refrigeration with the improvement of the coefficient of performance. Solar adsorption heat pump and refrigeration devices are of significance to meet the needs for cooling requirements such as air-conditioning and ice-making and medical or food preservation in remote areas. They are also noiseless, non-corrosive and environmentally friendly. For these reasons the research activities in this sector are still increasing to solve the crucial points that make these systems not yet ready to compete with the well-known vapor compression system.

There is an increasing interest in the development and use of adsorption chillers due to their various economic and impressive environmental benefits, enabling solar energy or waste heat to be used for applications such as district networks and cogeneration plants. Compared to adsorption systems
39
that require heat sources with temperatures above 100°C (zeolite– water systems, activated carbon–methanol systems) or conventional compressor chillers, a silica gel/water adsorption refrigerator uses waste heat with temperature below 100°C. This creates new possibilities for utilizing low temperature energy. 5. In May 2003

B.B. Saha, S. Koyama, T. Kashiwagi, A. Akisawa, K.C. Ng, H.T. Chua, have presented that Over the past few decades there have been considerable efforts to use adsorption (solid/vapour) for cooling and heat pump applications, but intensified efforts were initiated only since the imposition of international restrictions on the production and utilization of CFCs and HCFCs.

In this paper, a dual-mode silica gel–water adsorption chiller design is outlined along with the performance evaluation of the innovative chiller. This adsorption chiller utilizes effectively low temperature solar or waste heat sources of temperature between 40 and 95 _C. Two operation modes are possible for the advanced chiller. The first operation mode will be to work as a highly efficient conventional chiller where the driving source temperature is between 60 and 95 _C. The second operation mode will be to work as an advanced three stage adsorption chiller where the available driving source temperature is very low (between 40 and 60 _C). With this very low driving source temperature in combination with a coolant at 30 _C, no other cycle except an advanced adsorption cycle with staged regeneration will be operational.

The drawback of this operational mode is its poor efficiency in terms of cooling capacity and COP. Simulation results show that the optimum COP values are obtained at driving source temperatures between 50 and 55 _C in three-stage mode, and between 80 and 85 _C in single-stage, multi-bed mode. 6. In September 2004

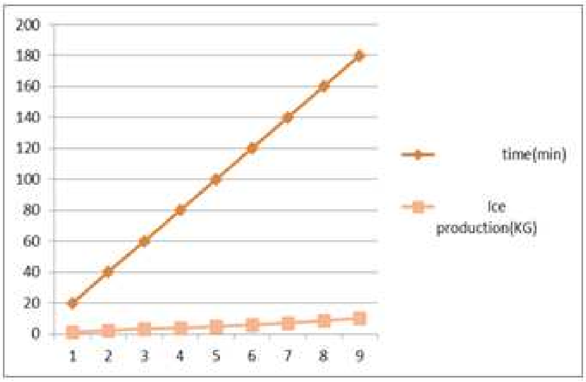
Y.L. Liu, R.Z. Wang*1, Z.Z. Xia, have presented that A newly developed adsorption water chiller is introduced and tested. In the new adsorption refrigeration system, there are no refrigerant valves, the problem of mass transfer resistance resulting in pressure drop along refrigerant passage in conventional systems when methanol or water is used as refrigerant can be absolutely solved. Silica-gel–water is used as working pair and mass recovery-like process is adopted in order to use low temperature heat source ranging from 70 to 85 8C effectively. The experiment results demonstrate that the chiller (26.4 kg silica-gel in each absorber) has a cooling capacity of 2–7.3 kW and COP ranging 0.2–0.42 according to different evaporating temperatures. Based on the experimental tests of the first prototype, the second prototype is designed and tested; the experimental data demonstrate that the chiller performance has been greatly improved, with a heat source temperature of 80 8C, a COP over 0.5 and cooling capacity of 9 kW has been achieved at evaporating temperature of 13 8C. 7. In 2008

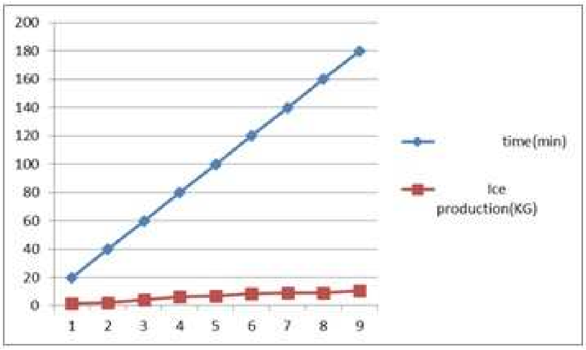
S.Gh. Etemad, B. Farajollahi, have presented that In the present experimental study heat transfer behavior of γ-Al2O3/water nano fluid in a shell and tube heat exchanger was investigated. The 40 experiments were done for the results obtained for a range of Peclet number and nano particle concentrations.

The experimental results indicate that the heat transfer characteristics of Nano fluid enhance significantly with increasing Peclet number. For example Nano fluid with 0.5% Nano particle volume concentration possesses about 20%, 56%, and 54% higher overall heat transfer coefficient, convective heat transfer coefficient and Nusselt number, respectively. Also there is an optimum for volume concentration in which the Nano fluid shows the maximum heat enhancement.

4 Figures, Tables and Photographs

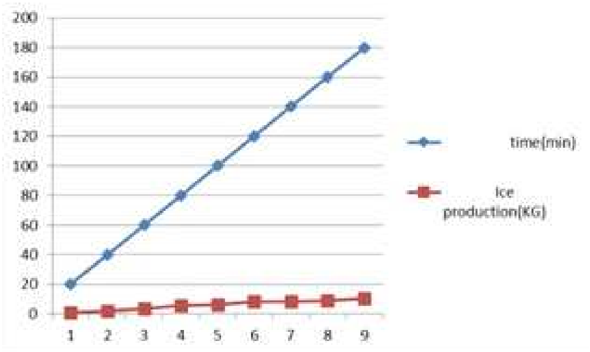
time(min)	Ice production(KG)
20	1
40	2
60	3
80	4
100	5
120	6
140	7
160	8.5
180	10

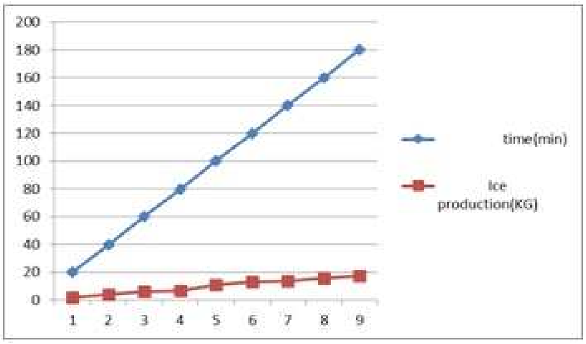




time(min)	Ice production(KG)
20	1
40	2.2
60	3.8
80	5.7
100	6.2
120	8.2
140	8.5
160	9
180	10.5

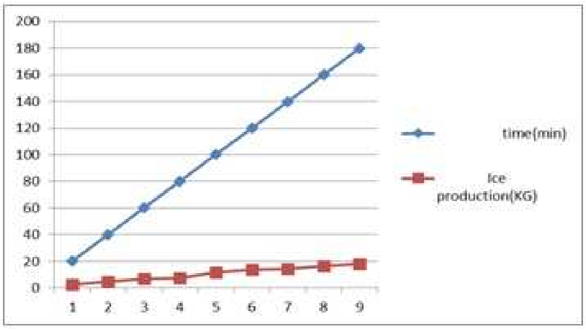
time(min)	Ice production(KG)
20	2
40	4.1
60	6.2
80	6.9
100	11
120	13
140	13.9
160	16
180	17.3



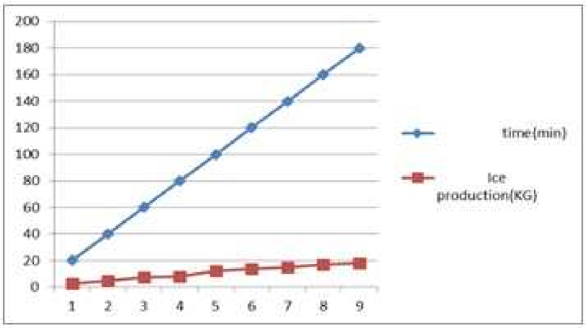


time(min)	Ice production(KG)
20	1.8
40	2.3
60	4.2
80	6.2
100	6.9
120	8.7
140	9
160	9.3
180	10.8

time(min)	Ice production(KG)
20	2.7
40	4.8
60	6.9
80	7.5
100	11.8
120	13.7
140	14.2
160	16.6
180	17.8



time(min)	Ice production(KG)
20	2.8
40	4.9
60	7.3
80	8
100	12
120	13.9
140	14.7
160	17
180	18



4. CONCLUSION

The WCR heat exchanger can be Lowering the initial water temperature in the ice maker's reservoir reduces the time required to cool the water to the freezing point, which reduces the entire ice making.

The increased production rate may be the most valuable impact to users with inadequate ice making capacity.

Reducing the cooling load on the ice maker should result in less "wear and tear," resulting in lower maintenance costs and longer equipment life

Acknowledgments

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Appendix A. Appendix

Appendices should be used only when absolutely necessary. They should come after the References. If there is more than one appendix, number them alphabetically.

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