

HEAT POWERED CYCLES 2016 EXTENDED ABSTRACTS

Editors

Ian W. Eames PhD, CEng, FIMechE

Michael J. Tierney PhD, CEng, MIChemE

Published by Heat Powered Cycles

Contents

Page	Paper	Author	Title
1	HPC960	Hisham Sabir	QATAR NATIONAL RESEARCH FUND: ACHIEVEMENTS AND OPPROTUNITIES
3	HPC990	Ruzhu Wang	WISE USES OF LOW-GRADE THERMAL ENERGY
5	HPC980	Giovanni Restuccia	ADSORBENT MATERIALS DEVELOPMENT FOR ADSORPTION HEAT PUMPS
8	HPC550	Adriano Milazzo and Federico Mazzelli	FUTURE PERSPECTIVES IN EJECTOR REFRIGERATION
10	HPC940	Philip Davies	ORGANIC RANKINE CYCLE FOR DESALINATION OF BRACKISH WATER BY REVERSE OSMOSIS
12	HPC950	Chritian Schweigler	IS THERE A NICHE FOR SORPTION HEAT PUMPS
15	HPC860	Christos N. Markides	TWO-PHASE THERMOFLUIDIC OSCILLATORS:ALTERNATIVE HEAT CONVERSION TECHNOLOGIES BASED ON UNSTEADY VAPOUR-PHASE ORGANIC FLUID CYCLES
17	HPC010	Huashan Bao, Zhiwei Ma, Ye Yuan and Anthony P. Roskilly	INTEGRATION OF CHEMISORPTION CYCLES AND TURBOMACHINERY FOR ELECTRIC AND THERMAL ENERGY STORAGE
19	HPC040	Jorge I. Hernandez, Roberto Best and Jacobo Galindo	AN ADVANTAGEOUS REPRESENTATION OF THE CRITICAL BEHAVIOUR OF AN EJECTOR COOLING SYSTEM BY DIMENSIONLESS PARAMETERS
21	HPC050	Brian Agnew and Ratha Mathkor	EXERGETIC ANALYSIS OF A SOLAR COGENERATION SYSTEM FOR SUSTAINABLE PRODUCTION OF ELECTRICITY AND COOLING
23	HPC060	Mohd Eschoul and Brian Agnew	A COMPARISON BETWEEN SED AND SINGLE RO DESALINATION PLANTS USING EXERGY AND ECONOMIC ANALYSIS
25	HPC070	Fathi Latrash and Brian Agnew	OPTIMAL SELECTION OF HFC, HCFC, HC and MIXTURE FLUIDS FOR RANKINE CYCLE ENGINES FOR LOW TEMPERATURE GEOTHERMAL APPLICATIONS
27	HPC080	Jan Albers and Felix Ziegler	CONTROL STRATEGIES FOR ABSORPTION CHILLERS IN CHPC-PLANTS ENSURING LOW HOT WATER RETURN TEMPERATURES
29	HPC090	G. Chen, O. Volovyk, V. Ierin and K. Shestopalov ^a	THERMODYNAMIC STUDY OF A MECHANICAL ANALOG OF THE HEAT-DRIVEN EJECTOR REFRIGERATION CYCLE
31	HPC100	Heike Schreiber, Uwe Bau, André Bardow	HEAT LOSS IN ADSORPTION THERMAL ENERGY STORAGE: MODELING AND EXPERIMENTAL VALIDATION

THERMODYNAMIC STUDY OF A MECHANICAL ANALOG OF THE HEAT-DRIVEN EJECTOR REFRIGERATION CYCLE

Guangming Chen^a, Oleksii Volovyk^{a,b}, Volodymyr Ierin^b, Kostyantyn Shestopalov^{a,b}

^a Ningbo Institute of Technology, Zhenjiang University,
1 QuianHu South Road, Ningbo City, 315100, Zhejiang Province, China; e-mail: gmchen@zju.edu.cn
^b Ejector Refrigeration Technologies Center, Odessa National Academy of Food Technologies,
112, Kanatnaya St., Odessa, 65039, Ukraine

INTRODUCTION

A review of the thermodynamic analyses of ejector refrigeration machines (ERMs) that combine power and cooling Carnot cycles in a wet vapor region shows that in some cases, the ERM cycle is presented by analogy to the cycle of the heat-driven vapor-compression refrigeration machine (VCRM) (Al-Khalidy, 1998; Angelino and Invernizzi, 2008; Sokolov and Hershgal, 1990). In addition, in some cases, the analyzed ideal cycles of ERMs contain liquid feed pumps intended to return the working substance to the vapor generator. Moreover, according to the descriptions of these cycles, the power to drive pumps comes from external sources of mechanical energy.

Considering the complex ERM cycle as one that combines both power and cooling cycles can simplify the study of this cycle. An analysis shows that there is currently no high-grade mechanical analog of the heat-driven ERM in which the mechanical energy needed for pumping the working substance is not supplied from the outside, but is made inside the cycle. In addition, the formulation of the mechanical analog of the ERM must maintain the work balance between the power and cooling cycles as well as the work balance between its components – the turbine, compressor, supercharger (compressor or pump), and expander.

The main objective of this research is to determine the correct diagram of the mechanical analog of the heat-driven ERM and its cycle.

In the paper a thermodynamic analysis of the vapor heat-driven refrigeration machine is carried out. A thermodynamic study of the mechanical analog of the ejector and heat-driven ERM is presented.

Fig. 1a represents a schematic diagram of a mechanical analog of the ejector as a device comprising a turbine, a compressor and a transmission device, in which the wet vapor after expansion in the turbine II is mixed with the saturated vapor from the evaporator VI and then the resulting mixture is compressed in the compressor VII.

The working substance with a mass flow rate of \dot{m}_p , produced in vapor generator I, enters turbine II, and it expands isentropically from pressure P_G to pressure P_E with work production \dot{W}_T (process 1-2). The vapor exiting from turbine II in state 2 is mixed in an isobaric-isothermal process at pressure P_E with the vapor coming from the evaporator VI with a mass flow rate \dot{m}_s in state 9.

The obtained expansion work \dot{W}_T is used through transmission device VIII without losses to drive compressor VII, in which the vapor mixture with mass flow rate $(\dot{m}_p + \dot{m}_s)$ is compressed in isentropic process 3-4 to pressure P_C , and then the mixture enters the condenser III.

In this way, the processes and the energy balance are realized in a turbine-compressor unit shown in Fig. 1a which is the same as those in an ejector.

Schematic diagram of a mechanical analog of the heat-driven ERM, in which the proposed device is used, is shown in Fig. 1b.

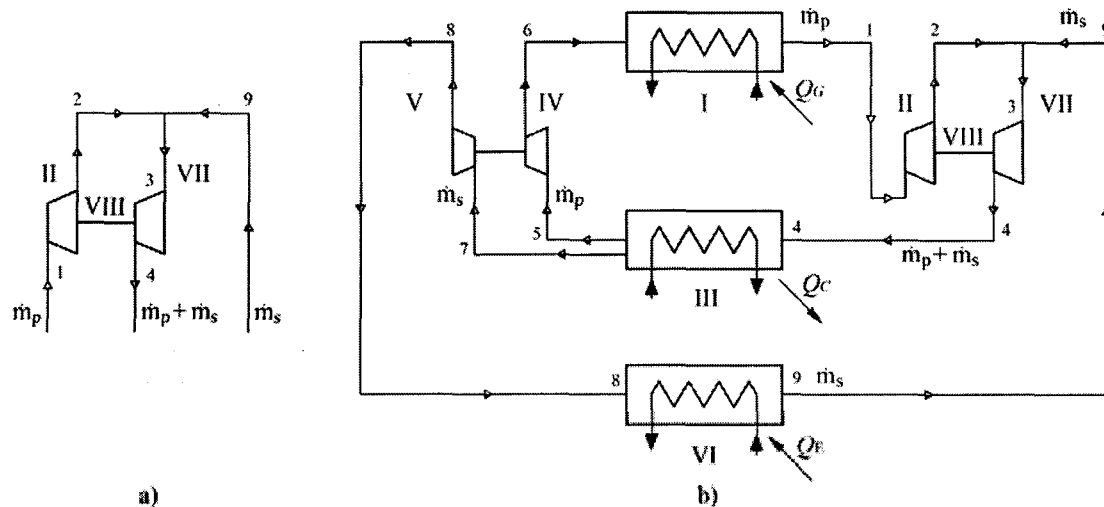


Figure 1: Schematic diagram of a mechanical analog of the ejector (a) and heat-driven ejector refrigeration machine (b):
I – vapor generator; II – turbine; III – condenser; IV, VII – compressors; V – expander;
VI – evaporator; VIII – transmission device.

For the detailed analysis of the cycles, theoretical calculations for refrigerants with different types of saturation curves were performed. Ammonia (R717) was studied as a wet-type substance and butane (R600) as a dry-type substance. Also, the results for water (R718) as a wet-type substance are presented. The features for construction of the cycle for dry and wet working substances that maintains the work balance between the power and cooling cycles are discussed. The cycles were studied for the evaporator cooling capacity Q_E of 1 kW at the generating temperature $T_G = 100$ °C and the evaporating temperature $T_E = 8$ °C in the range of condensing temperatures T_C from 28 to 40 °C.

Analysis shows that for the correct interpretation of the cycle of a mechanical analog of the ERM in compliance with the work balance between power and cooling cycles, the ratio of primary to the secondary streams must be changed. The mechanical analog of the ERM has the lowest value of this ratio compared to the ideal cycles of the heat-driven VCRMs.

The proposed cycle of the mechanical analog of the ERM is equivalent to the ideal cycle of the heat-driven ERM in which the mechanical energy required for the circulation of the working substance is not supplied from the outside but is produced and supplied from inside the cycle. This cycle provides the basis for further thermodynamic analysis of the theoretical and real cycles of the ERM, with an aim to develop methods for their improvement.

REFERENCES

- Al-Khalidy, N., 1998. An experimental study of an ejector cycle refrigeration machine operating on R113. *Int. J. Refrigeration* 21, 617-625.
- Angelino, G., Invernizzi, C. 2008. Thermodynamic optimization of ejector actuated refrigerating cycles. *Int. J. Refrigeration* 31, 453-463.
- Sokolov, M., Hershgal, D. 1990. Enhanced ejector refrigeration cycles powered by low grade heat, Part 1. System characterization. *Int. J. Refrigeration* 13, 351-356.