REHOS Cycle at a Glance Sept 2018

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Abstract:

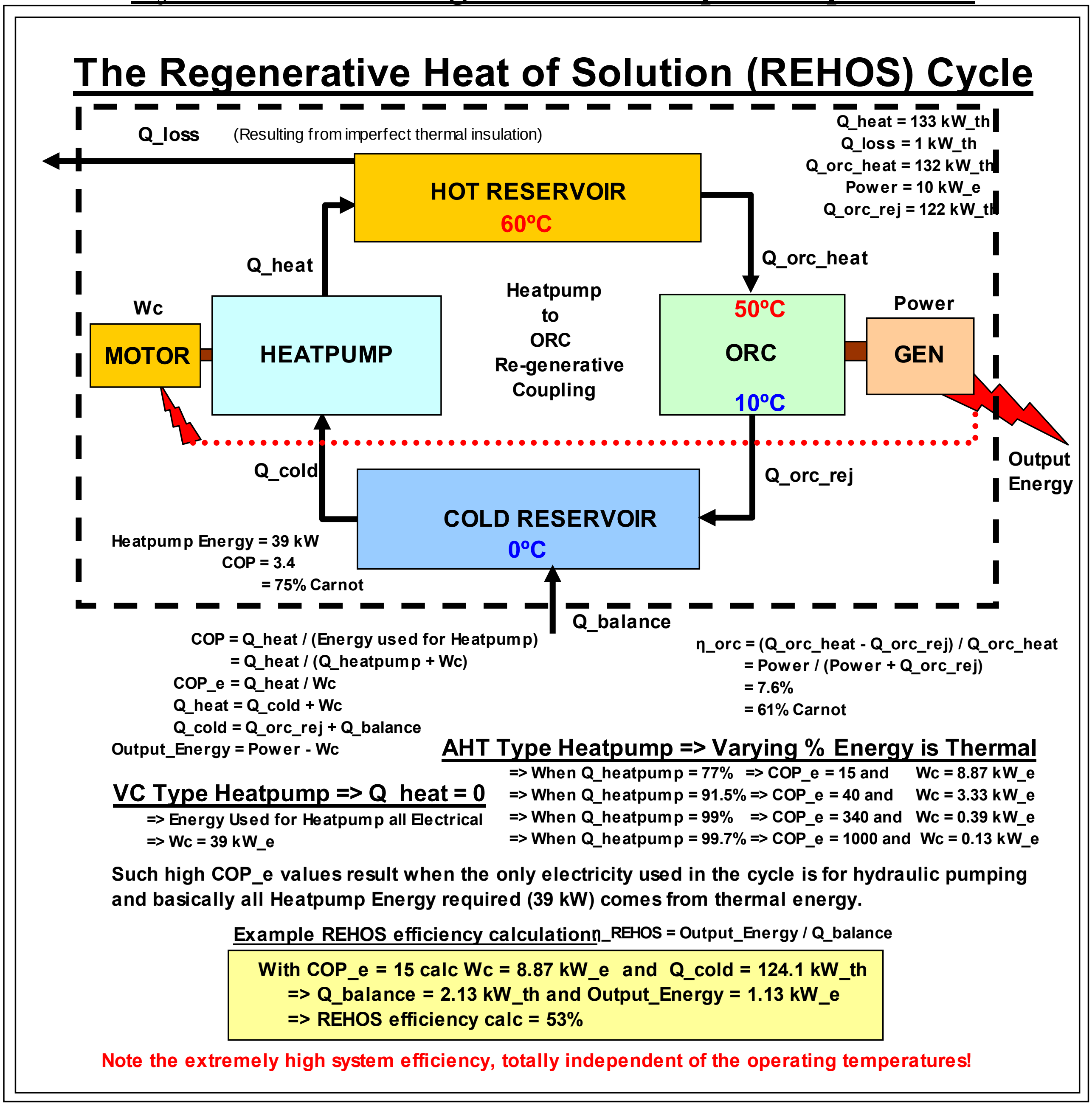
The REHOS thermodynamic power cycle consist of two distinctly different sub-cycles, combined regeneratively, namely an Absorption Heat Transformer (AHT) type heat pump, pumping low-grade heat from an external waste heat source, up to higher temperature, and a simple Organic Rankine Cycle (ORC) utilizing the pumped, higher temperature heat to power a turbine.

The heatpump make use of an isobaric, sliding temperature binary column we call a Bubble Reactor, utilizing a zeotropic liquid mixture like NH3 in Aqua. This allow the complete absorption and regenerative re-use of the waste heat rejected by the ORC power cycle. The waste heat rejected by the ORC is utilized and "upgraded" to higher temperature and used for the high pressure ORC boiler.

Due to this complete regeneration of the rejected heat, the REHOS cycle efficiency is extremely high and totally independant of the operating temperatures. It also ensure that the only heat loss from the system comes from conduction and radiation of heat from the working surfaces due to imperfect thermal insulation. The REHOS cycle does not have a "heat rejection" condenser like the standerd ORC or Rankine cycle.

Heat re-circulation around the REHOS cycle is therefore fairly high (some 10 x the power output) while the heat input to the cycle stay very low, being just higher than the electrical power output of the cycle. The cycle thermodynamic efficiency is also nearly independent of the ORC sub cycle efficiency (and therefore the turbine isentropic efficiency).

Cycle Overview using Realistic example Temperatures



The different conventions around the coefficient of performance (COP) and heatpump efficiency calculations have been described in the publication [8], and different types of heat driven heatpumps were elaborated on in my publication [9].

A specific design of a vapor ejector jet type compressor used in a AHT-Hybrid type heatpump for use as a primary sub-cycle in REHOS Power Cycle was published as [10], while a description of a completely compressor-less AHT type heatpump was recently completed in the publication [11] with a COP_e value in excess of 1000, as more than 99.7% of the energy for powering the heatpump is thermal energy. Only the liquid pressure pump use electricity!

References:

1. Hybrid Heat Pump for Waste Heat Recovery in Norwegian Food Industry, Stein Rune Nordtvedt, Institute for Energy Technology, Instituttveien 18, N-2027 Kjeller Bjarne R. Horntvedt, Hybrid Energy AS, Ole Deviks vei 4, N-0666 Oslo, Jan Eikefjord, John Johansen, Nortura AS, Rudshøgda, Norway, Stein.Nordtvedt@ife.no. *(This paper was published in the proceedings of the 10th International Heat Pump Conference 2011.)*. This paper is also published as part of the IEA Handbook [2], page 57 - 61.

2. Thermally driven heat pumps for heating and cooling, compiled and edited by Annette Kühn (Ed.) as the Universitätsverlag der TU Berlin 2013, as the IEA Handbook available as handbook ISBN (online) 978-3-7983-2596-8 at email publikationen@ub.tu-berlin.de

3. Experimental Evaluation of a single-stage Heat Transformer used to increase Solar Pond's Temperature, by W. Rivera of Centro de Investigación en Energia-UNAM, P.O. Box 34, 62580, Temixco, Mor. , Mexoco and published in Solar Energy Vol 69, No. 5, pp. 369 - 376, 2000.

4. Industrial Heat Pumps for High Temperature Process Applications *(A numerical study of the ammonia-water hybrid absorption-compression heat pump)* by Jonas Kjaer Jensen, Ph.D. Thesis, Kongens Lyngby December 2015, DTU Mechanical Engineering, Technical University of Denmark.

5. Development of the Hybrid Absorption Heat Pump Process at High Temperature Operation, by Anders Borgås, Masters Thesis June 2014, NTNU Department of Energy and Process Engineering, Norwegian University of Science and Technology.

6. An Introduction to the Kalina Cycle, reprinted by Henry A. Mlcak, PE , first published in PWR- Vol.30, Proceedings of the International Joint Power Generation Conference, with editors: L. Kielasa and G.E. Weed, Book No. H01077-1996.

7. Analysis of Absorber Operations for the 5 kW Ammonia/Water Combined Cycle by Sirisha Devi Govindaraju as Thesis Presented to the Graduate School of the University of Florida in Partial Fulfillment of the requirements for the Degree of Master of Science, 2005.

Previous Publications:

8. The follow-up document "Clarification of COP calculations for Absorption Heat Transformer (AHT) Type Heat Pumps.pdf" was written by Johan Enslin (to enhance the Executive Overview paper) in March 2018 and published on my website http://www.heatrecovery.co.za/.cm4all/iproc.php/Clarification of COP calculations for Absorption Heat Transformer (AHT) Type Heat Pumps.pdf

9. The document titled "Comparison of various Modern Heatpump Technologies for unlocking Commercial Value from Ambient Heat_rev4.pdf" was written by Johan Enslin in April 2018 and published on my website http://www.heatrecovery.co.za/.cm4all/iproc.php/Comparison of various Modern Heatpump Technologies for unlocking Commercial Value from Ambient Heat_rev4.pdf

10. The document titled "The Proof-of-Concept Model of the REHOS Ejector Heat Pump Part 1.pdf" was written by Johan Enslin in April 2018 and published on my website http://www.heatrecovery.co.za/.cm4all/iproc.php/The Proof-of-Concept Model of the REHOS Ejector Heat Pump_Part 1.pdf

11. The Syphon Bubble Reactor Heat Transformer as Heatpump in the REHOS Cycle is a document published in July 2018 by Johan Enslin on my website http://www.heatrecovery.co.za/.cm4all/iproc.php/The Syphon Bubble Reactor Heat Transformer as Heatpump in the REHOS Cycle_rev1.pdf

12. Website for Heat Recovery Micro Systems where the above publications are available from: www.heatrecovery.co.za