Use of Low Grade Heat for Energy and Water Recovery

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1. Introduction

Two key issues for the future of societies are the supply of energy and the supply of water. Both topics are tightly connected to each other: energy conversion uses and consumes water; water supply requires energy. In order to act in a sustainable way, we have to intensify energy recovery and water recovery (e.g., re-use of grey water), and we have to develop the technological opportunities which are hidden in combination and interdependence of both. Moreover, we have to integrate architecture and urban planning. Our teaching and research activities are oriented towards these goals.

2. Key Features

During the energy conversion or in chemical engineering processes, considerable amounts of waste heat become available. Modern concepts - which often comprise absorption heat pump technology - allow conversion of waste heat into useful energy products resulting in important energy savings. Please note that the same concepts are valid and are being used for conversion of solar heat or geothermal heat into cold, too.

From an economic point of view, an important figure to remember is that the conversion of low-grade heat to cold is about 10 times more efficient than the conversion to power, and it is also cheaper. This is why we want to put some stress on cooling in this poster presentation.

The conversion to cold most commonly is accomplished by absorption chillers. Fig. 1 shows a 10kW prototype absorption chiller which produces cold from either solar panels or from the waste heat of a cogeneration engine. Performance data which have been gathered in the laboratory with using the waste heat of a small stationary gas engine are shown in Fig. 2.

Fig. 1. Absorption chiller under test at TU Berlin, operated by cogeneration engine (upper left picture) or solar collectors (upper right picture).

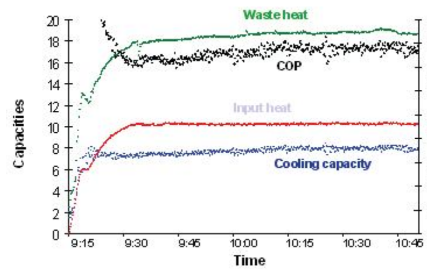

Fig. 2. Absorption chiller, operated by waste heat (77/58°C) of a cogeneration engine.

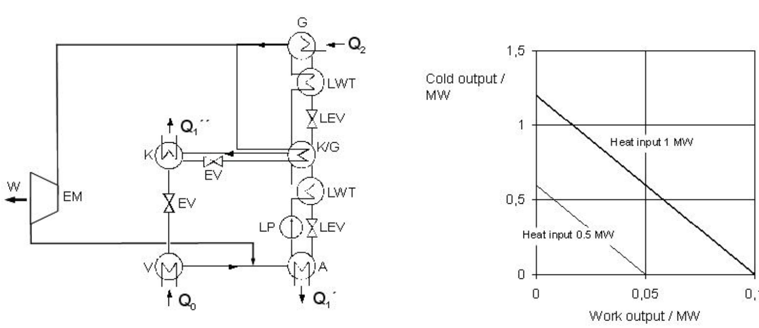

Fig. 3. Cycle for producing cold Q_0 and power W from waste heat Q_2. Flow scheme (left) and performance (right). A: Absorber; EM: Exp. machine; EV: Exp. valve; G: Generator; K: Condenser; LEV: Solution valve; LWT: Solution hx; V: Evaporator.

Another important option is the direct and simultaneous production of cold and power. Here, the state of the art is much less advanced. However, the prospect is extremely interesting, power and cold being the most relevant energy products in many countries. Fig. 3 (left) shows a process diagram of a possible cycle. It is a double-effect absorption chiller with the addition of an expansion machine between high and low pressure of the chiller. A rough estimate of the corresponding balance of plant is depicted in Fig. 3 (right). It can be noticed that the ratio between cold production and power production can be adjusted to the needs freely.

Up to now, in order to dispose of the waste heat wet cooling towers are used predominantly. The use of dry coolers is preferential from a water saving point of view, but it also shifts the required temperatures to run the absorption chiller upwards into a less attractive domain. Future research effort will be focused on the use of those chillers within very hot and humid climates with dry cooling, which today is still quite restricted. It becomes obvious that water consumption is directly linked to energy consumption.

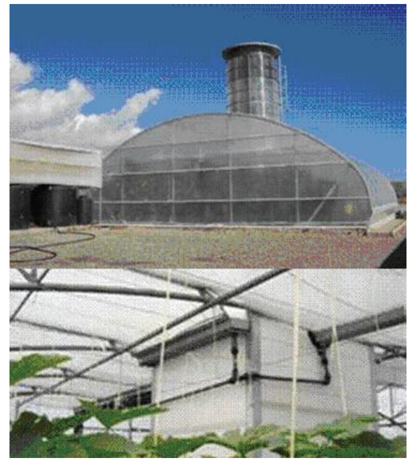

Fig. 4. "Watergy" greenhouse with closed water circuit and greywater purification.

There are heavily water-consuming applications such as greenhouses. It is a long-term goal to reduce the irrigation to a minimum. Within a EU-funded project the technological possibility of a greenhouse with closed water circuit is demonstrated ("watergy", Fig. 4). The water circulates evaporating and condensing within the greenhouse. By this distillation process, even grey water or brackish water can be purified, as a side effect. In the project, buffering or storing the latent heat of the condensing water for energetic purposes is investigated also. In a future research project, cooling will be implemented.

3. Conclusions

There is a wealth of possibilities to make use of low grade heat sources to provide cooling or power. Some are on the way to market, some are still only projections. What is required today is much more research in that field. The same statements hold for water saving technologies. As a final remark we want to state that the key issue both in technology and in economics of these systems is efficient heat transfer. There also, much more basic understanding still is required.

4. References and Bibliography

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Author Biographies

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