GAS HEAT PUMPS IN GERMANY

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0 Abstract

Gas engine-driven heat pump: YORK INTERNATIONAL, Mannheim, produces heat pumps with a heating capacity of 400 kW up to 1000 kW. The COP is in the range of 1.6 with a development potential up to 2.2. Gas absorption heat pump: The GESELLSCHAFT FUER GASKLIMA, Maintal, the German partner of ROBUR, Zingonia, Italy, will distribute the ROBUR heat pump of 40 kW heating capacity with a COP of 1.6 based on the produced absorption chiller. Gas diffusion absorption heat pump: BUDERUS, Wetzlar, tested its heat pump with 3.6 kW heating capacity for low energy houses with success and will go in the market in 2003. Gas adsorption heat pump: VAILLANT, Remscheid, develops a zeolite heat pump with 10 kW heating capacity which consists of two modules that transformed the periodic process in a quasi-circle process. Field testing is planned by the end of 2002 and market entrance by 2005. Gas driven Vuilleumier heat pump: Based on the Vuilleumier process VIESSMANN-Werke, Allendorf, developed a heat pump with 20 kW heating capacity and a COP in the range of 1.6.

1 Introduction

With the drastic increase of the crude oil prices the heat pumps are topic again. In the last years the electrical and gas heat pumps got distinct technology advancement, nevertheless the share of the market is negligible at the time. While the electric heat pumps have their importance, the gas heat pumps represented just in a slight measure. But it accepted the challenge of competition.

The following types of gas heat pumps are represented in the German market respectively in a developmental stage:

- gas engine-driven heat pumps,
- absorption heat pumps incl. diffusion absorption heat pumps,
- adsorption heat pumps
- Vuilleumier heat pumps.

2 GAS ENGINE-DRIVEN HEAT PUMPS

The compressor is driven by a gas engine in contrast to electric heat pumps, shown in the scheme of a gas engine heat pump (Figure 1). The heat output of the heat pump cycle and the engine cycle is used together. That means, that the heat output at the condenser is combined with the heat of the cooling water and the waste gas. Three temperatures levels, which can be used differently, are available:

- sensible heat in waste gas → of 600 °C result in available heat of 100 °C
- cooling water heat → produce available heat of 90 °C
- condenser heat → supply available heat of 40 °C to 50 °C

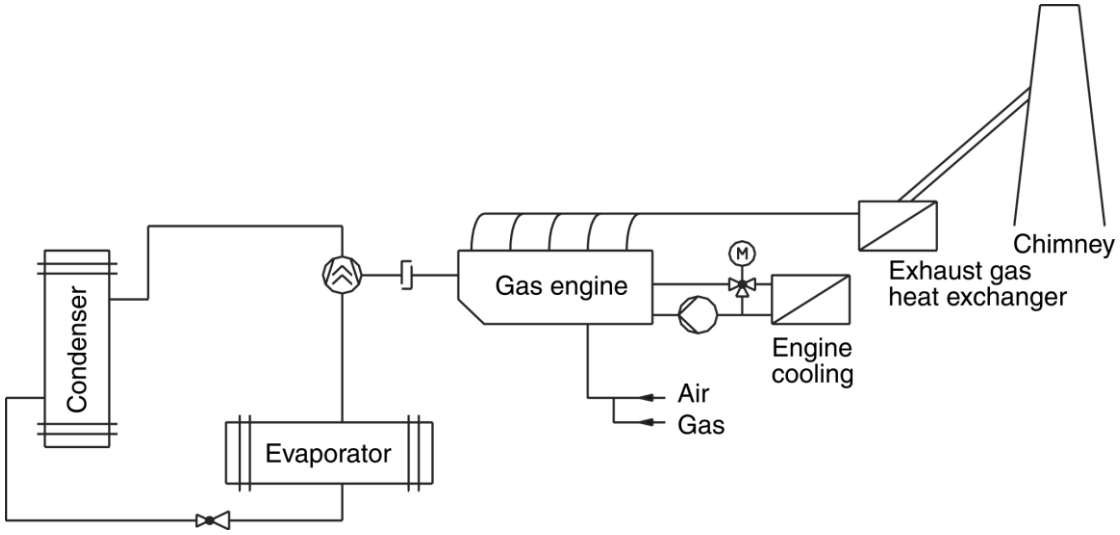

Figure 1: Modular mimic display of a gas engine-driven heat pump
(Source: York International)

Combining the gas input of 100% and the environment or waste heat in the height of 70% yield a heating capacity of 160%. Environment heat, condenser heat (36%) as well cooling water and waste gas of the engine (54%) will give the total heat capacity.

YORK INTERNATIONAL in Mannheim delivers gas driven heat pumps from 400 kW to 1000 kW nominal heat capacity for dehumidify, heating and water heating for indoor swimming pools, and for district heating concepts, also. It is mentioned here a project in Waren an der Müritz from 2 x 600 kW capacity in combination with thermal water as heat source.

Developments for optimization put onto gas engines as well as component of heat pumps (Figure 2). A distinct increase of the efficiency is obtained with boosted Mager engines and direct injected natural gas engines. York's new developed screw-type compressor with power slide makes it possible to change the internal volume and compression ratio while running. With it an optimal efficiency by changing of the cooling demand can be always reached.

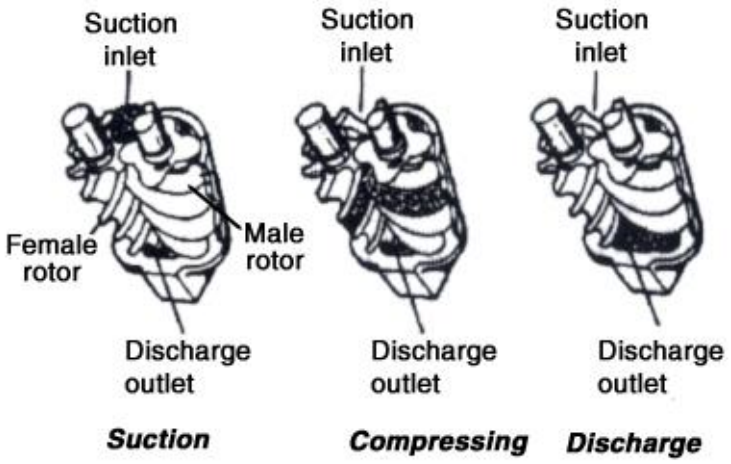

Figure 2: Double rotor
(Source: York International)

By advancement an increase of heating value is from 1.6 to a range of 2.2.

3 ABSORPTION HEAT PUMPS

Gas engine-driven and gas absorption heat pumps are essentially different in the drive. The gas engine-driven compressor is in the absorption technology replaced by a thermal drive existing in generator, absorber, a solution pump, which keep the cycle running, and a throttling device between high pressure and low pressure site. In both technologies are a condenser and an evaporator for the working fluid with the according condensation heat output and heat input from the environment in the evaporator.

Improvement of technology leads to an absorption process, which became a very complex scheme by the connection of numerous heat exchangers (Figure 3). The work of the last years is expressed in a lot of heat exchange processes.

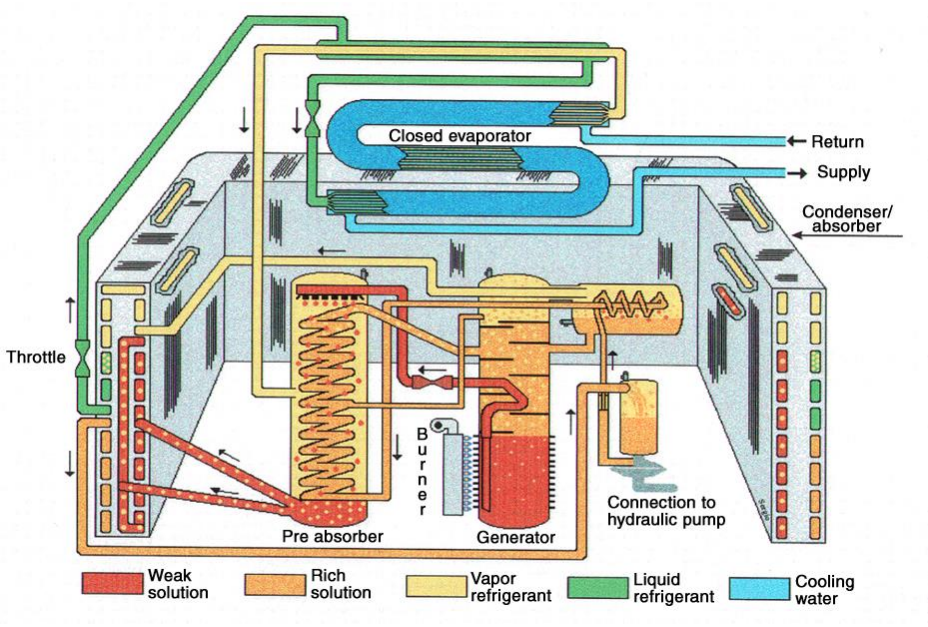

Figure 3: Absorption process " GAX – Implementation"
(Source: Gesellschaft für GasKlima mbH)

The cooperation of the "Gesellschaft für GasKlima", Maintal, with Robur, Evansville, USA, a producer of gas driven absorption water chillers, leads to the possibility to increase the efficiency and at the same time to reduce the costs. The Robur water chiller (Figure 4) integrate the GAX-heat exchange cycle (Generator Absorber Heat Exchanger), a connection between the generator cycle and absorber cycle, which attains an improvement of the efficiency of 37%.

Figure 4: Absorption chiller
(Source: Robur)

Further developed absorption heat pump has an efficiency, which is in the range of 1.5 and partly higher. Beyond, the serial production of water chillers can be used, by which the costs can be reduced by 5'000 EUR. In summer of 2002 Robur will enter the market with a new 40 kW heat pump based on their absorption chiller. The "Gesellschaft für GasKlima" will distribute this heat pump in Germany.

4 DIFFUSIONABSORPTION HEAT PUMPS DAHP

The diffusion absorption heat pumps from Buderus, Wetzlar, (Figure 5) have no more solution pumps. Helium is added as gas to support the cycle, which creates a buoyancy between absorber and evaporator, that means bubble effect, to drive the cycle of the working fluid. This system is technically interesting – without moving parts – but it is limited in its capacity.

Because of a lower ammonia pressure in the evaporator helium as additional gas makes it further possible to decrease the evaporator temperatures. Evaporating temperatures to –25 °C allows then by lower temperatures to input heat in the cycle, by which the efficiency in the range of low heat source temperatures get favour.

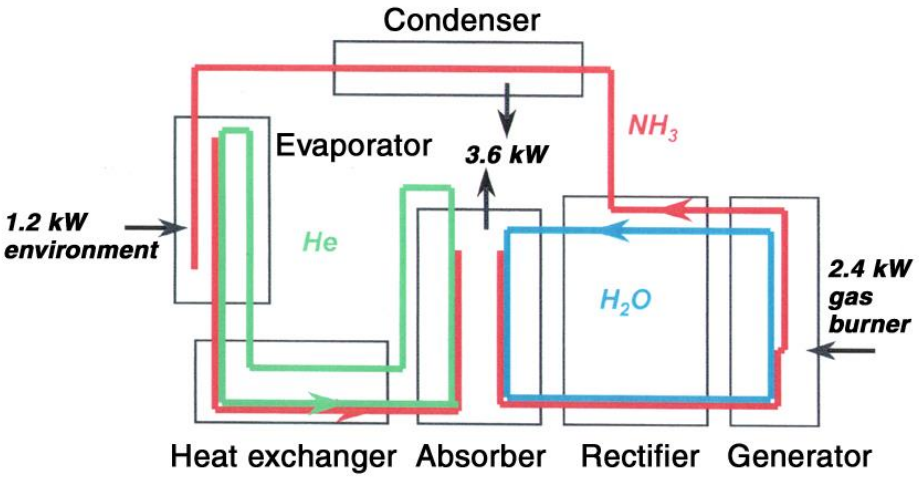

Figure 5: Process flow diagram of a diffusionabsorption heat pump
(Source: Buderus Heiztechnik)

One module has a heat capacity of 3.6 kW. With the appliance you can heat up, prepare warm water and cool. An environment heat input of 1.2 kW and a gas input of 2.4 kW leads to a COP of 1.5. The environment heat input correspond to a cooling capacity of 1.2 kW.

This appliance is developed in Switzerland. Absorption refrigerators were the base, which are in use in caravans, but also in every hotel, because they are noiseless and working with helium as additional gas. Buderus gained the license. The subsidiary company in the Netherlands produces the heat pumps. State of the technology is that 60 heat pumps were tested in a field test

in the Netherlands and another 40 in Germany. The first experiences are positive. The introduction in the market is planned in 2003.

For the field test the DAHP was connected with an 11 kW condensing boiler (Figure 6). For the use in one-family low-energy houses the complete demand can be covered with 3.6 kW. The heat demand can be also compensate in houses with higher heat consumption in transition period. But for the warm water preparation a higher heating capacity will be needed. Therefore, an 11 kW condensing boiler was integrated.

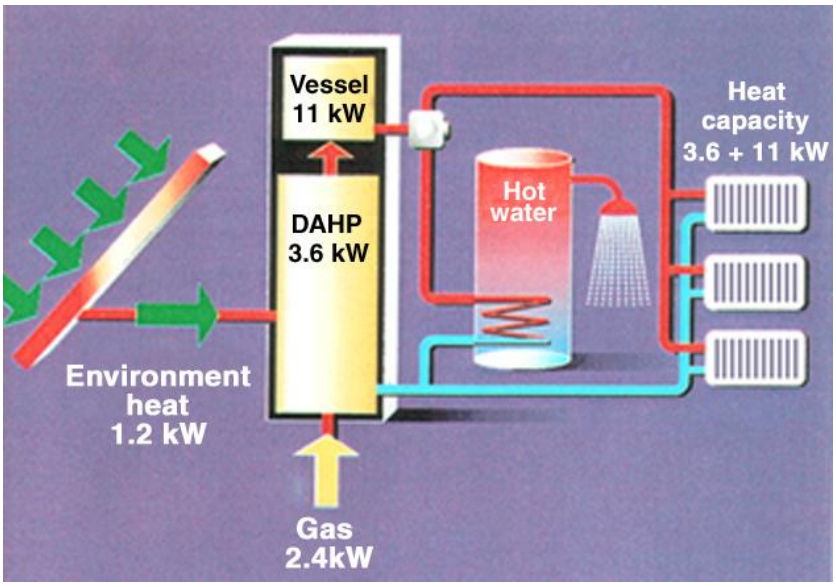

Figure 6: Heat system of a diffusion absorption heat pump

The COP reaches 1.5 while the heat pump running and all together with the boiler it results in an annual efficiency of 132%. In opposite the condensing boiler alone has 107%. With the combination a quite good efficiency can be reached in the case of that the heat pump cannot cover the heat demand, completely.

5 ADSORPTION HEAT PUMPS

The company Vaillant, Remscheid, develops an adsorption heat pump, the so called „Zeolite-water heating appliance“. Considerations were made, how to reach energy savings highly with a simple cycle by using the adsorption technology (Figure 7).

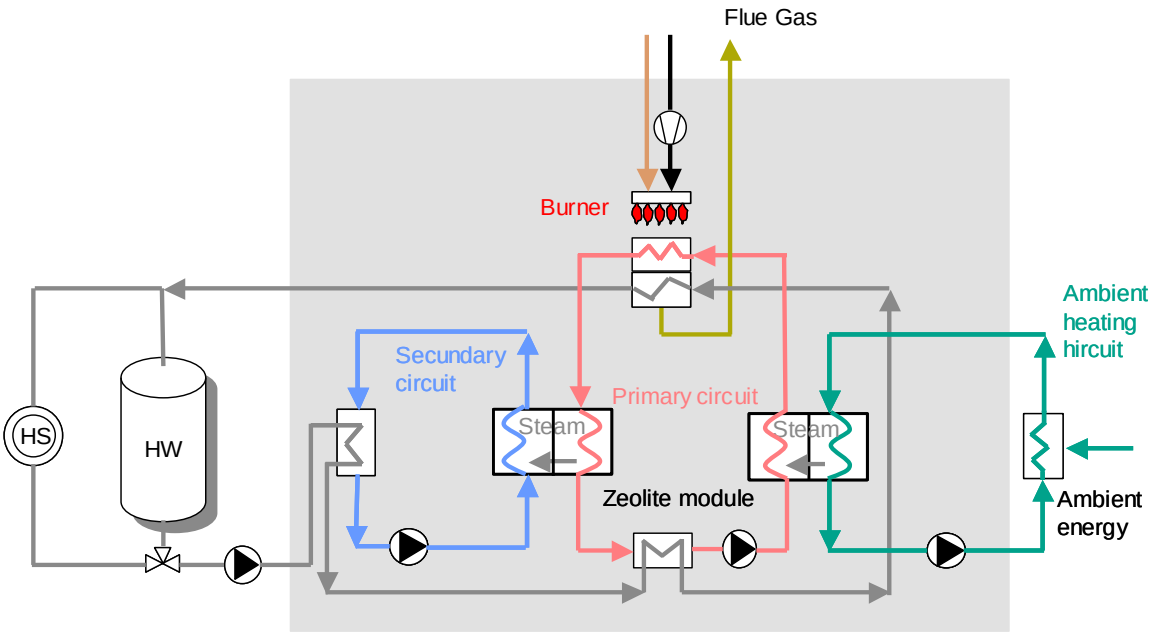

Figure 7: Process flow diagramms of a zeolite water heat pump
(Source: Vaillant)

The adsorption process works with a granulate made of zeolite, a ceramic material consisting of aluminum dioxide and silicon dioxide, which adsorbs water as working fluid. By heat input the water desorbs as water vapour, after condensation in the condenser the water evaporates in the evaporator, whereby taking up heat from the environment. Because the so-called adsorbens is here a solid it is called adsorption.

In the case of absorption heat pumps it is a question of a cycle process. The adsorptions process nevertheless takes a periodic course. But the process is changed in a "quasi-cycle process" by installation of two modules. In which one module works as a desorber and one as an absorber. Each of the modules has a diameter of 150 mm and a length of 800 mm. The process is controlled by a step motor device.

The advancement consists essentially in an efficient heat transfer. It takes a fin pipe with a slight width of slit. The slit is not bigger than the granulate thickness, so that a thin granulate layer lies on the pipe. The heat transfer and the penetration depth become very well.

One reference to expected COP is shown in Figure 8. The zeolite-water appliance can reach a COP in the range of 1.35, i.e. 30% more than a condensing boiler. The heating output will be 10 kW at first.

This year the first appliances will be constructed for running in a field test. A series wise production is planned by 2005.

Performance data

- Suitable for 1- or 2- family homes
- Efficiency: 135 %
- Flow temperature: 20 to 75 °C
- Heating output: at first 10 kW,
  5 to 25 kW later
- Dimension: 1610 x 615 x 590
- Life cycle of system: 15 years
- Annual maintenance (clean PHX only)

(Source: Vaillant)

6 VUILLEUMIER HEAT PUMPS

The Vuilleumier heat pump uses a regenerative gas cycle process as drive, which is named after the French inventor. This process can be seen as a further compressor construction beside the mechanical and thermal compressors used in heat pumps (Figure 9). The gas flows through regenerators between different temperatures levels. All the time heat is taking up from the environment respectively from the gas combustion.

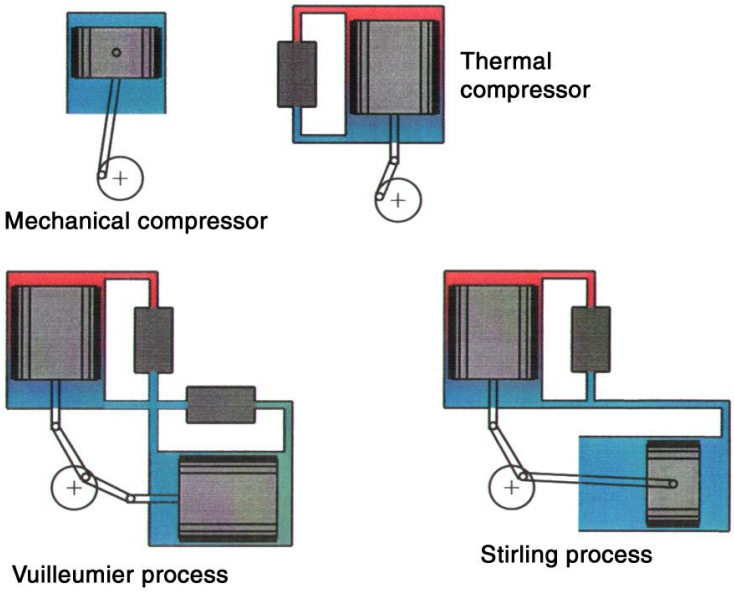

Figure 9: Compressor construction
(Source: Viessmann)

The well-known Stirling engine with a displacing and a compressor piston, which mechanically driven also can be used as a heat pump. Vuilleumier heat pumps work in opposite to Stirling engines with two displacing pistons. The drive is thermal done by gas combustion.

The Viessmann-Werke, Allendorf, advances a Vuilleumier heat pump in the low power range. At time exist a serial design for a 20 kW appliance (Figure 10). The COP lies in the range over 1.6.

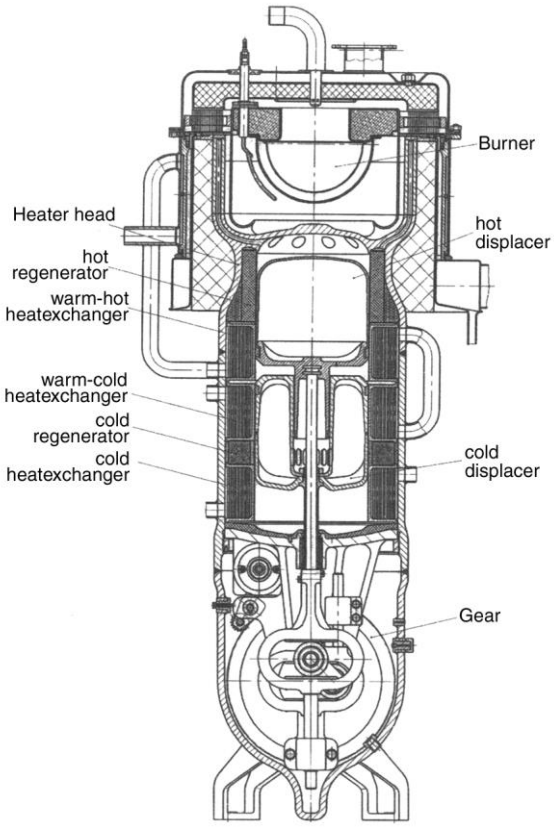

Figure 10: Serial design of a 20 kW Vuilleumier heat pump
(Source: Viessmann)

7 Conclusions

Well-known producer of refrigeration systems and heater are prepared for the challenge of the energy market – e.g. increasing energy prices and conditions for the CO_2 - reduction – with gas heat pumps.