GAHPs for Heating & DHW

KEYPOINTS

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GAHPs for Heating & DHW

Foreword

• European, American, Asian typical residential system installations are different: they point to different product design (habits, climates)
• Heating, DHW and cooling modes
• Hydronic, air and (multi) DX distribution systems
• It takes the next generation or two to change the average engineer+ dealer + plumber & end user mindset (acknowledge it if you want a product to be sold)
GAHPs for Heating & DHW
the European case

Europe (residential):

• the heating unit provides both heating & DHW
• gas fired boilers are the mainstream residential heating appliances
• hydronics for heating systems [very good fit for sorption systems]: radiators and floor heating
• (eventual) air conditioning is a separate system
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opportunities and challenges  

Europe (residential):

- Huge opportunity for GAHPs in the residential market [not going into this subject]

- The more a GAHP unit differs from a 1-to-1 replacement unit for a boiler, the smaller the fraction of the potential sales will be
GAHPs for Heating & DHW capacities and temperatures  Europe (residential)

• Heating average residential load is within 5-10 kW
• Heating capacity installed is 24-28kW [required for instantaneous DHW]. But you will get a 24 kW boiler even if you have a DHW buffer tank… Big mismatch between load and heating capacity is perceived as normal
• temperatures up to 70°C are required in most systems [retrofit >90% of sales] when outside temperature is at minimum design point.
GAHPs for Heating & DHW capacities and temperatures  Europe (residential)

• Minimum 45-50°C required for typical 0-2°C outdoor ambient operation in real retrofit applications
• Unless you have a low temp heating floor, what is the meaning in real world of having a superefficient heat pump delivering full output capacity at very mild water and mild outdoor temp when you do not need it, and running on electrical/gas backup when you need it?
• Even if you have a floor heating system, then you will anyway need DHW [and in this case DHW will require high temperatures]. Moreover even floor heating systems typically run with water for bathrooms towel radiator @ 50°C and use mixing valves for the floor lower temp.
• DHW account for a significant and increasing percentage of the energy consumption share
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Allies and foes  Europe (residential)

• Cost and performances of GAHPs are to be referred to gas boilers not to compression heat pump. Boilers are the real challenge.
• Compression heat pumps are allied [in spreading the knowledge of more advanced systems]
• The real constrain vs. the boiler are:
  • the low temperature (outside) source
  • Sizing the HP for the right heating capacity + DHW buffer tank
  • Matching the building load with the HP capacity [they go opposite directions with varying outdoor temperatures]
GAHPs

a reference

• GAHPs are already available for sale in Europe for residential use.
• For example the efficiency of the Robur k18 GAHP is A++ according to the EN12309. This translates roughly in GUE >150% (or a refrigeration cycle COPs>0.60) with a thermal lift of 50°C
• The ratio of the weight per nominal power output is 11kW/kg (complete air source unit)
• The cost for the end user (not installed) is <500 euro/kW (and Robur in not a residential appliances manufacturer)
• Just to set a reference for the next generations of products
GAHPs pumping technology

- Solution pumping is the most overlooked, expensive and reliability dominant component
- For a residential GAHP the solution pumping system will have to be leak thigh (no rotating sealing), handle low flow rate saturated liquid (cavitation), sustain high pressure lift (>25 bars) and have no service (at least on the solution side) for 40,000 hours. A daunting task.
- Proven pumping systems do exist
GAHPs heat exchangers

• Cost, convenience, installation space are proportional to the weight of the unit: weight reduction is mandatory
• Thermo dynamical cycles require high or sub ambient pressure: reducing weight implies going to small diameters
• Miniaturization is the key of future developments
• At the end everything translates in new HX design and manufacturing process
GAHPs operating conditions & controls

• GHAPs have to operate in an extremely wide range of operation for both heating and DHW (definitely a wider range than a cooling unit)
  • The evaporator temperature has to match the outside low (or hot) temperature source from -30°C to +40°C
  • The condenser has to operate from 5°C up to 70 °C
  • The solution circuit has to work at full input down to 15 % of the nominal capacity
• In addition to the «traditional» CCV (concentration control vessel) and static restrictors, active flow controlling devices can improve a lot both the efficiency and operation control
GAHPs operating conditions & controls

• Operating with a rectifier requiring fluid pair (H2O-NH3) has always been a complication and an efficiency reduction.

• It is also a feature that has the potential of solving some other way difficult working conditions. I mean the ability of working with a 70°C condenser while keeping pressures below 20 bars, and still getting some evaporator capacity.
GAHPs corrosion

• Corrosion. Knowledge is driven mostly by (expensive) experience on very long lasting testing on several units.
• Testing on actual working units is significant. Testing on material samples in vessel with lab reproduced conditions is not reliable.
• It is actually a combination of corrosion and erosion and takes places mostly/only in the generator above 140°C. For H2O-NH3 up to 160°C can be handled with benign corrosion inhibitors. Above 160°C is a different story.
• Geometrical design of the firetube/generator matters a lot.
GAHPs advanced cycles

• Big development in the 80s and 90s; a lot of patent issued. Most of new advanced cycles have been only numerically evaluated, mainly for air conditioning conditions, sometimes with oversimplifying assumptions due to computing capabilities/program development available at the time.

• Need for accurate numerical re-evaluations/reviews of major cycles families with updated numerical tools and for the European heat pumping set of conditions.
GAHPs advanced cycles

• Most patents have now expired: everything is available free of charge.
• Only a limited number of advanced cycles has been actually tested [for example see Donald Erickson work].
• The experimental test actually done were often conducted by doctoral candidates followed by academics with limited experience/time. Given the above conditions even getting the basic single effect cycle working properly would be a challenge.
• Need for accurate advanced cycle (HX, components) testing in (a hopefully larger group of) skilled lab engineering facilities.