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

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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.

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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.