System build up and description of the 2-stage DAIKIN Altherma Flex Type Air-to-Water heat pump for multi family houses

François Bruggemans
DAIKIN Europe Brussels Office
Chaussée de Mons 1424 B-1070 Brussels-Anderlecht (Belgium)
bruggemans.f@bxl.daikineurope.com

Market situation

Over the recent years, the heating market has experienced some significant changes, mainly driven by the upward trend of energy costs and increasing ecological awareness amongst the general public, and amplified by several regulations and incentive schemes. Heat pump technology has been able to profit from this favourable market situation, and this has lead to the successful introduction of heat pumps in general, and air to water heat pumps in particular, as an ecological and economical alternative for traditional combustion based heating.

Economies of scale, easy transfer of available technologies from air to air heat pumps and boiler systems, shorter decision and sales routes and other reasons have put the market focus for air to water heat pumps for residential heating towards solutions for individual single family houses. Looking at building statistics, we see however that these individual houses only account for about half of the existing dwelling stock and even less of the new built dwellings.

For multi-family houses and apartment buildings, the integration of air to water heat pumps systems seems not so straightforward. Up till now, there were two options for integrating air to water heat pumps in multi-family houses or apartment buildings, each with several merits and demerits:

a) the installation of small individual air to water heat pumps in each apartment:

This option gives the greatest flexibility towards the end-user, since he will be fully in control of his own heating system. The end-user can individually decide when he wants to heat (or to cool). The hydraulic installation can remain simple, and there is no need for collective piping. Cost allocation is easy, providing that each apartment has its own electricity meter. The consumption of the heat pump is billed as part of the total electricity consumption of the apartment. The biggest limitation will lay in the installation of the evaporator units. Indoor installation will very often be impossible or unwanted. Outdoor installation might have an impact on the building aesthetics or cause noise disturbance towards direct neighbours (e.g. outdoor units on each terrace). Remote and grouped installation of multiple small outdoor units might be limited by available space (avoid airflow interference between units) or maximum allowable piping lengths.

b) the installation of a large capacity collective heat pump:

With this option, the end-user has no longer full individual control of his heating system. Cooling will only be possible in specific cases, especially if the heat pump is also used for the collective preparation of domestic hot water. Hydraulic installation will require a

more complex distribution system, preferably with some buffer to eliminate hunting in times of low demand. Furthermore, if precise cost allocation by heat measurement is required, the hydraulic installation needs to be designed with a single entry to each apartment. Running and other operational costs will need to be allocated by fixed division keys or by individual heat meters. Installation of the fewer but bigger outdoor units will be less influenced by space limitations.

Preferred emitters for apartments remain radiators (or fan coils if cooling is required). The additional screed thickness an underfloor heating installation will require can in extreme cases reduce the number of storeys which can be built within the height limitations of the building. The use of radiators will require higher operating water temperatures.

Typically, apartments in multi-storey buildings will have lower heat loads, due to smaller outdoor wall surfaces and it is even more likely that additional cooling will be required during summer.

Concept explanation

In response of the typical requirements explained above, DAIKIN has developed a 2 staged R410A / R134a cascaded heat pump system for apartment buildings. The concept consists of high capacity VRV® based R410A outdoor units with heat recovery, in combination with individual small capacity R134a cascaded heat pumps. The commercialised product program includes a range of 5 outdoor units with 22.4 to 44.8 kW of heating capacity (20 to 40 kW in cooling) and 2 capacities of indoor units (5.6 and 9 kW heating capacity), available as heating only or as reversible units (with 5 and 8 kW of cooling capacity respectively).

In heating mode, both the R410A cycle of the outdoor unit as the R134a cycle of the indoor units will be operational. R410A will be evaporated in the outdoor heat exchanger, and will condensate in the R410A/R134a heat exchanger of the indoor units. The R134a will condensate in its turn in an R134a / water heat exchanger, allowing water temperatures from 25°C to 80°C. This temperature range allows the use of all types of heat emitters.

By using a cascade of 2 heat pumps, it becomes possible to overcome big temperature differences between source and sink temperature. R410A has better performance at low evaporation temperatures, but the performance drops at high condensation temperatures, whereas R134a will perform better than R410A at high condensation temperatures, but will be low performing with low evaporation temperatures.

Since the R134a cycle evaporates on the R410A heat exchanger, its operation and performance are basically independent from the ambient temperature. The R134a cycle will operate in function of the heating demands (both capacity as temperature), whereas the R410A operation will be focussed on maintaining a semi-fixed intermediate condensation temperature. At low ambient temperatures, the R410A compressor speed will boost to provide sufficient condensation enthalpy to the R410A/R134a heat exchanger[1], leading to only a small capacity drop, unlike single cycle heat pumps.

The capability of heating up the water to high temperatures is also exploited during domestic hot water preparation. The basic mode remains the same as for space heating, except that a 3 way valve will divert the heated water to a heat exchanger coil in a domestic hot water cylinder. Domestic hot water temperatures up to 75°C are possible, without the need to revert to joule effect heaters. A 200 liter tank can be heated up from 15°C to 60°C in 70 minutes, with a COP of 3.0. Once heated, a total of 320 liter of water at 40°C is available for use.

For cooling operation, the R134a circuit of the indoor units is bypassed, and heat is transferred directly between the system water and the R410A low pressure liquid in a separate heat exchanger, comparable to a standard R410A reversible heat pump and providing chilled water of 5 to 20°C.

Due to the use of heat recovery capable VRV® outdoor units, the heat transferred to the R410A circuit during cooling operation of a unit, can again be transferred to the R410A/R134a heat exchanger of any of the connected indoor units. As such, this heat absorbed from cooling can be recovered for the preparation of domestic hot water, or for the space heating of other apartments. To maximize the heat recovery potential, the indoor units can be parametered that the standard temperature setpoint for domestic hot water is bypassed to higher value when heat recovery is active.

The use of VRV® outdoor units allows for a big capacity modulation range, which is necessary in apartment applications (e.g. in summertime when only one unit is operating to prepare hot water). The combination of a variable Proportional Integral (PI) control system and

1 See also the article "New technology for high temperature heat pumps", David Steen, Jan Logghe, REHVA Journal November 2009

refrigerant pressure sensors abbreviate control steps into smaller units to provide precise control in both small and larger areas, continuously adjusting the circulating refrigerant volume in response to load variations in the connected indoor units. This allow also the indoor units of operating independently of each other, even with regards to their operation mode (heating or cooling), offering the end-user full control over his own heating system.

The indoor units are conceived as plug and play units. All hydraulic are included in the unit, which can directly be connected to the emission system of the apartment. The domestic hot water tank is a separate unit, but can be installed on top of the indoor heat pump unit by means of quick couplings, minimizing the installation workload and installation space.

Indoor and outdoor units are connected by a three pipe refnet system, with the possibility to use headers and Y-joints. The installation of this piping is less restrictive and less space consuming compared to a hydraulic distribution system for a collective boiler or heat pump.

By using this system, apartments now also can benefit from the advantages of heat pumps with regards to lower running costs and reduced environmental impact. The basic principles of heat pumps do apply. The quantitative merit is of course dependent of local variables, such as energy prices and CO_2 emission factors for electricity production. Projected in an example for Belgium for instance, we can see a potential running cost reduction of 36%, a reduction of 35% in primary energy use and a 71% in CO_2 emissions when compared to oil.

Conclusion

By combining two advanced heat pump technologies, DAIKIN has developed a unique heat pump concept for apartment buildings offering a unique combination of differentiating advantages:

- High efficiency at high Tlwc (space heating, DHW heating)
- Cooling function
- Providing optimal comfort (individual control per apartment)
- Space and time efficient installation
- Reduced environmental impact
- Savings on running costs

Most of these advantages are not only applicable and interesting for apartment buildings, but also in other applications where a combination of heating, cooling and DHW exist, such as hotels, offices, student dorms, wellness centers, big villas and so on.

Application examples

a) Hyde Park - 7 storey apartment building in Ostend (Belgium)

This would be the typical application for the DAIKIN Altherma Flex Type heat pump. Each apartment has a heat load between 4 and 6 kW, and can as such efficiently be heated by a single indoor module, combined with hot water tanks. The southern oriented large windows make cooling a necessity in summer, allowing for heat recovery in this period. The total heating capacity of 32.5 kW at -7°C can easily be provided by a single outdoor unit, conveniently installed on the roof.

b) HALTON project – social housing project UK

This project consists of the limited refurbishment of 4 buildings, each with 6 or 7 apartments. The existing radiators had to remain in place, which required higher water temperatures. Each of the 4 buildings can be equipped with a single outdoor unit. No cooling is required.

c) HORSELAND Project – France - Manège complex with hotel villas, conference rooms and spa/wellness functions.

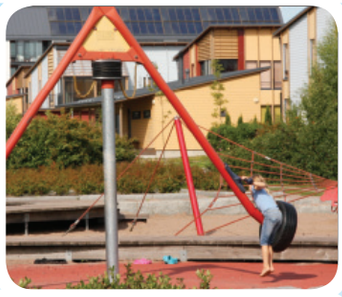
Each hotel villa is equipped with several indoor units with associated hot water tanks. Heating and cooling is done by a ceiling heating/cooling system. Dimensioning has been done on the hot water requirements. In a single building, all the indoor units are hydraulically interconnected to one circuit, which distributes heating or cooling to each individual room.

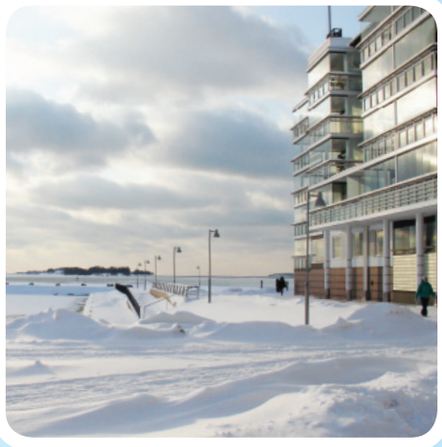
d) XT Sports club – Legnano (Italy)

Replacement of old gas boiler and R22 chiller. Ten indoor units connected to two outdoor units provide the necessary cooling/heating of the fitness hall and the domestic hot water for 16 showers. Huge potential for heat recovery, due to a long cooling season (more than 6 months) and continuous hot water demand from the showers. The domestic hot water tanks will be connected to solar thermal panels.

SB11 HELSINKI

World Sustainable
Building Conference





Organised by

October 18–21, 2011

SB11.org

Building better human environments And a better future

Our competence and focus is on indoor climate, comfortable living, clean water, health and efficiency. We support the building industry with **Uponor** radiant heating and cooling and flexible plumbing solutions. These solutions are designed to preserve natural environment through efficient use of renewable energy sources.

We partner with professionals and together we create better human environments.

And a better future.

www.uponor.com
communications@uponor.com

uponor
simply more