FIELD EXPERIENCE IN HEATING AND COOLING SYSTEMS BY INTEGRATING RENEWABLE AND TRADITIONAL ENERGY.

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NATURAL FIVE LINE-UP.

Mayekawa was founded in 1924 and is to-day one of the world's largest industrial refrigeration companies. It actively promotes the 'NATURAL FIVE' refrigerants, including ammonia, CO2, hydrocarbon gasses, air and water. Mayekawa is active in ammonia compressors for more than 85 years, for hydrocarbons and CO2 for more than 40 years.

In the 'NATURAL FIVE' overview table the different applications are summarized for each natural refrigerant from freezing, cooling, air conditioning and heating.

SYSTEM APPLICATIONS.

The 'SYSTEM APPLICATION' overview table shows the most actual trends with "NATURAL 5" refrigerants starting at lowest temperatures by using AIR, HC's, CO2/NH3 cascade compression, followed by CO2 brine pump system/NH3 2-stage and single stage compression followed by the NH3, HC's heat pumps and the CO2 transcritical heat pumps.

GEOTHERMAL SOURCED HEAT PUMP

Operating field case based on natural refrigerant AMMONIA.

Geothermal water-sourced HEAT PUMP to produce 60°C hot water for district heating.

For this district heating application the design requirement was to obtain 480kW hot water of 60°C to be heated from 40°C. As heat source spring water of 40°C is available to be cooled to 35°C.

The selected piston type compressor model N6HK(design 50bar) operating with ammonia at TE/TC=+30/+65°C(PS/PD=11.7/29.1bara) generates a heating capacity of 270, resp.480kW at compressor-speed 900, resp.1600 rpm by means of frequency convertor. The corresponding absorbed motorshaft power amounts to 40, resp.75kW depending on the operating speed, giving a final heating-COP of 6,75; resp. 6,4.

The condenser is a plate in shell execution operating at 65°C NH3 condensing temperature and producing 60°C hot water from 40°C.

The evaporator is a flooded plate in shell type execution evaporating at 30°C NH3 evaporating temperature and producing geothermal source water-outlet of 35°C from 40°C. The NH3 suction gas separator is mounted on top of the evaporator.

The oil system in this heat pump unit contains an oil separator(10ppm/weight) with oil level switch, an external oil tank and oil recovery system. The NH3 expansion is realized with a lineair valve controlled by the NH3 liquid level in the NH3 separator.

The pressure-instrumentation-diagram (pid) no ME-24057/1 shows the reciprocating compressor with main drive motor and –coupling, the oil system containing oil separator(demister type) and oil buffer tank complete with instrumentation, control system and safety devices.

Pid ME-24057/2 shows the flooded plate in shell type evaporator with external suction gas separator and the plate in shell condenser. The electronic lineair expansion valve, the oil recovery tank installed on the oil sump of the low pressure side of the separator.

The unit layout ME-24058 shows the compressor-motor set with the oil separator, condenser and evaporator with suction separator.

A photo of the installation at site is shown in the presentation.

The ‘COSTS’ table gives an overview of the operation- and investment cost :

Between the conventional system using gasoil to produce the hot water and the heat pump system.

To evaluate the savings the yearly heating capacities are calculated for both systems :

1.692mWh gasoil against 225mWh electricity.

Based on the energy cost of 0.05€/kWh for gasoil and 0.150€/kWh for electricity the total energy cost per year is calculated for both systems :

84.600€ for oil heating against 33.750€ for heat pump heating

The installation cost of the heat pump system excluding the water-system amounts to 150.000€.

This means that the yearly saving on running cost equals to : 50.850€, which corresponds with a payback time of approx. 3.

Conclusion :

It is clear that this application leads to a very important reduction on use of fosil energy : the heat pump unit consumes approx.15% of the energy which is needed by using a gasoil boiler, i.e. energy consumption reduction with 85%, which also directly applies on the reduction of CO_2 emmisions.

Here again is shown that the investment is recovered by the saving of energy within a period of 3 years what is very common these days with optimal designed heat pump systems.

ADSORPTION CHILLER WITH RENEWABLE ENERGY

The adsorption cycle is explained in the PT diagram. The refrigerant used for this process is water.

The key component of the adsorption chiller is the adsorbent "Zeolite".
The adsorbent has the feature to adsorp(take up)(1->2) water when it is cooled down (4->1). It will desorp(release) water(3->4) when it is heated up (2->3).

The Zeolite is present in the central heat-exchanger which is connected with an evaporator and a condenser with valves.

During the adsorption-phase the evaporator is connected with the Zeolite heat-echanger: cooling of the Zeolite results in evaporation of the water in the evaporator (waterchiller) and adsorption of water by the Zeolite.

During the desorption-phase the condenser is connected with the Zeolite heat-exchanger : heating of the Zeolite results in desorption of the water and condensation of the water-vapor in the condenser.

In order to obtain a continuous flow and chiller function two Zeolite heat-exchangers are foreseen with batch operation in vacuum with a cycle time of 250 seconds.

Principle scheme's and photo's are shown in the presentation.

Mayekawa started originally with Silica-gel type adsorption from 1990 till 2006. Since 2009 Zeolite type adsorbers are installed. In 2009 Mayekawa was Award Winner in Japan for Technology Price of Environment Protection by Nikkei BP.

The temperature depency of the adsorbent is compared between different adsorbents and shows that Zeolite has a large temperature dependency and 3.5 times more water adsorbing capacity than Silica-gel.

The Zeolite heat-exchanger is made of copper tubes with aluminium fins which are coated with Zeolite. With the former silica-gel execution the silica-gel was fully filling the gaps between the tube-fins.

The standard temperature conditions and technical specifications are shown in the overview tables based on 3 adsorber models of 110kW, 215kW and 430 kW.

Hot water temperature range : +60°C to +80°C,
Cooling water temperature range : below +35°C,
Chilled water temperature range : +5°C to +25°C

ADSORPTION CHILLERS - FIELD CASES :

Air –Conditioning of Shopping Center with Solar Heat Source.
The plant scheme shows the adsorption unit with

Hot water circuit :

300m2 solar heat collectors producing hot water in temperature range of +65°C to +80°C, buffered in a hot water tank at +60°C to +75°C;

Cooling water circuit :

Cooling tower producing water of +29°C.

Chilled water circuit :

Supplied with chilled water of +9°C from the adsorption unit to the air conditioning coolers in the Shopping Center, and chilled water return of +14°C to the adsorption unit.

The temperature variations in the adsorber nr 1 and nr 2 in batch operation are shown in the graph illustration per following curves :

Chilled water inlet & outlet, condenser water inlet & outlet, hot water inlet & outlet, cooling water inlet & outlet

The energy-saving effect is shown in the overview table for :
Adsorption – Centrifugal - Air-cooled – Absorption
on a calculation basis of approx.350kW chilling to +7->+9°C
and shows that the adsorption chiller has the best COP of 10.8
and the lowest CO2 emmision of approx. 104 ton/year.

The key-features of Adsorption “Zeolite” Chillers are :
1. Use of natural refrigerant, water ODP=0 & GWP=0
2. Heat source : low grade (waste) hot water (effective for +60°C to +80°C)
3. Production of chilled water between +5°C and +25°C with a cycle time of 250 seconds.
4.Newly developed adsorbent “Zeolite” (coated thin layer & life-long use)
5.Very low electricity consumption (only refrigerant & vacuum pumps)
6. Lighter weight and compact dimension compared to Mycom Silica-gel version
7.Easy handling and lower operation and maintenance costs
8.No certified or qualified personnel is required
9.No vibration or noise problems