A New Absorption Machine for Both Cooling and Heating

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Abstract.

The paper, in very concise way, shows the results of a research and development activity in the field of absorption heat pumps carried on by ENEA together with the Italian firm NET. The activity was aimed to the construction and testing of a new water-ammonia machine for both chilling and heating purposes in the tertiary sector.

The experimental performance data of the first 11 kW chilling machine are compared to those of the R22 compression machines in terms of COP, Primary Energy Ratio and TEWI.

Introduction.

In the early 80's, ENEA, the current Italian Agency for the New Technologies, Energy and the Environment, started a research and development programme aimed to the diffusion of the heat-pumping technologies.

During the following years, several experimental experiences were carried on in the field of absorption heat pumps, producing an original Know-How; various demonstration machines and about twelve patents.

In 1994 ENEA met SRS, a private Engineering Society: a Proposal for the EC Thermie Project (BU-34/95) was then presented in order to develop cooling and heating absorption machines in two sizes: 11 and 25 kW (chilling).

In 1995 the Project started.

In 1997 SRS created the NET consortium, for the production and sale of the machines.

in 2001, after about six years, the Project BU-34/95 ended, with the compliments of EC for the good experimental results achieved with the 11 kW machine.

The experimental tests on the 25 kW are still ongoing, outside the original contract, due to the large time expenditure.

1-Why a new machine?

- Good market trend in Italy for water-ammonia absorption chillers (+7 %) for the tertiary sector, since 1991 (ENEA 1998).
- Absorption machines have better performance as heat pumps rather than chillers.
- In Italy exists a certain difficulty to install electrical connections of adequate power for air conditioning.
- In our country the natural gas has a widespread distribution.
- The natural gas suppliers apply special lowered tariffs for gas air conditioning.
- The Mediterranean climate is particularly favourable for both heating and cooling absorption machines.

- The production cost is almost the same as a chilling only machine.
- The market asks for machines that do not need chilling towers.

2-Why not before?

- The absorption technology is still too much “new”.
- The components for the machine are generally not available.
- The demand for air conditioners had a strong increase only recently.
- The kind of knowledge involved is not usually held by air conditioning manufacturers (Chemical Engineering).
- Manufacturers are inclined to run the risk only if a competitor starts the production with success.
- The research cost is high.
- The production costs of the machine appear to be slightly high.
- The presence of ammonia at high pressure is a concern.

3-General Specifications.

Cycle:	Water-Ammonia (single stage)
Type:	Water-Water (built in internal fan unit)
Operation:	Chilling and Heating
Chilling Power (1):	11/25 kW (cold water 7-12 °C)
Heating Power (2):	22/50 kW (warm water 45- 55 °C)
Feed:	Natural Gas (direct fired)
Power Control:	Twin Burner with flame modulation.

(1)Summer Temperature : 35 °C (50% R.U.)
(2)Winter Temperature: 7 °C (87% R.U.)

The new machines are intended as substitute of the electrical compression units, commonly used as chillers and sometimes also as heat pumps in the tertiary sector.

At present, for this specific sector, the market, as an alternative, offers water-ammonia or lithium bromide-water absorption chillers that in some case can be operated also as simple heaters during the cold season.

Inside this niche, the lower cost and the possibility of avoiding the chilling tower, makes the water-ammonia machine by far the preferred by the customers.

In order to permit an easy chiller/heat pump reversibility it was decided to choose a water-water unit coupled with an internal fan unit, switched by a special 8-way water valve.

To comply with the flow rates of pure ammonia required by the two different working conditions, specially in case of part load operation, it was decided to use two burners, lighting only one of them during the cold season.Furthermore it was necessary to insert an automatic level control on the ammonia condensate vessel, to permit a correct condensing operation.

4-Process and connection layouts.

The scheme adopted for the process side, named ISPCA 3 bis (Corallo 1992) is based on a simple single stage water ammonia cycle with absorber and condenser cooled by water in sequence.

It was found that this solution is probably the best compromise to reduce size and costs of the whole machine.

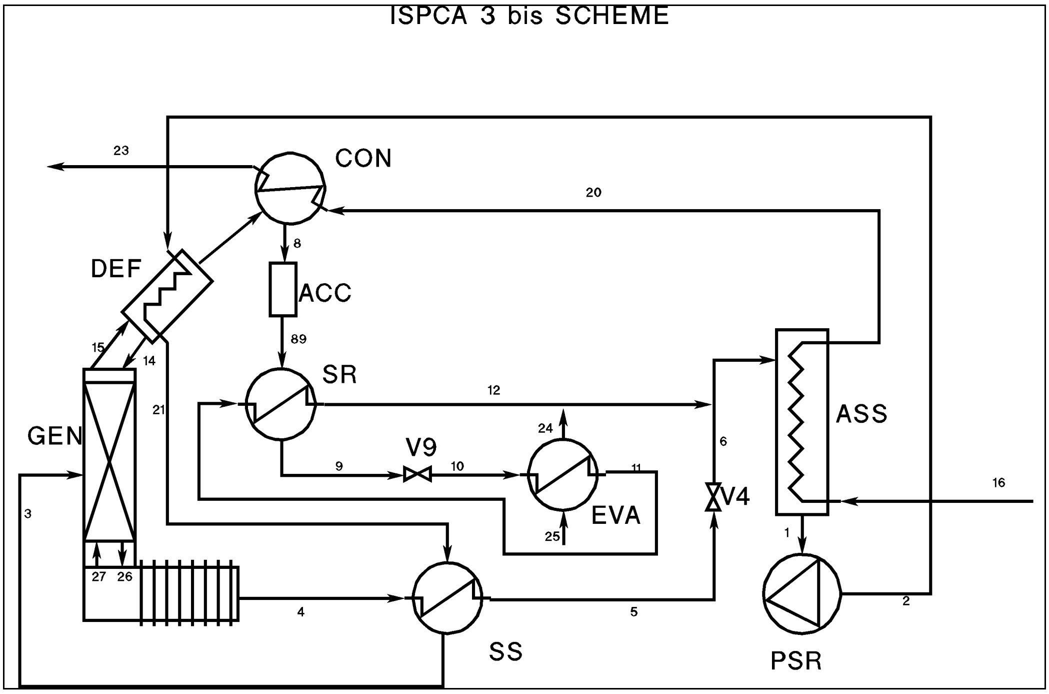

Figure 1. Process Layout

The connection scheme is very simple, the change of operation from chiller to heat pump is made possible by a special 8-way valve connected to points 1-8.

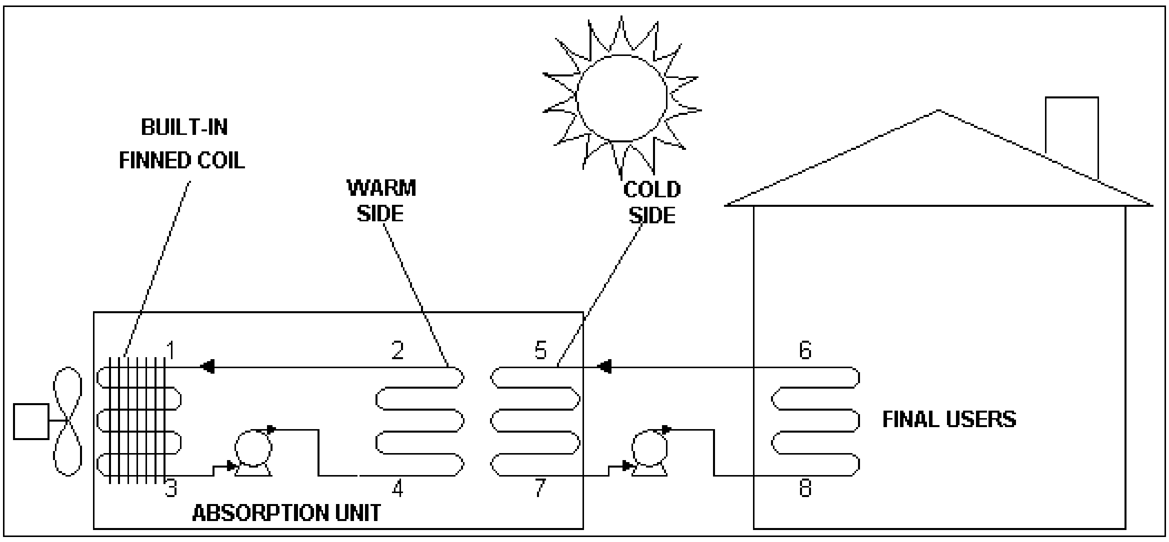

Figure 2. Connections Layout

5-Photos

Photo 1. ENEA’s Laboratories near Casaccia Center.

Photo 2. The 11 kW Machine - Dimensions: 85 x 155 x155 cm

Photo3. The 25 kW Machine (lab. prototype) - Dimensions: 100x180x200 cm

Photo 4. The NET's Factory

6-Performance

In figures 3 and 4 are shown the experimental COP (Cardinali 2002) of the 11 kW machine in cooling and heating mode, compared to those of a commercial R22 water/water compression machine as reported on the manufacturer's catalogue.

The inlet temperatures were fixed as explained in the general specifications paragraph: 12 °C for the cold water in chilling mode and 45 °C for the warm water in heating mode.

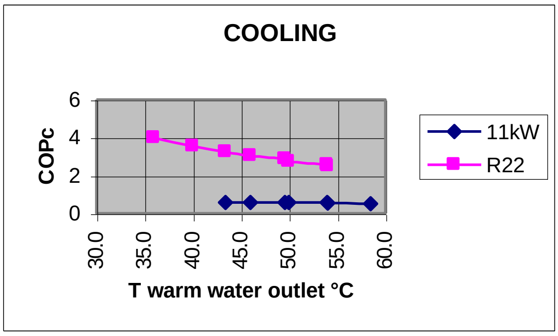

Figure. 3

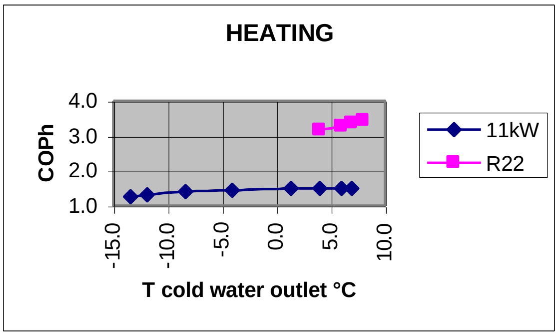

Figure. 4

In figures 5 and 6 the comparison is made on the basis of the primary energy ratios, assuming an overall efficiency of transformation from fossil fuel to electricity equal to 33 %.

The PER don't take into account the electrical consumption of pumps and fans; part-load and refrigerant loss efficiencies are not applied.

The data of the 11 kW machine are derived by the best averaged experimental COP using a combustion efficiency equal to 85 % as experimentally verified on the final 11 kW machines.

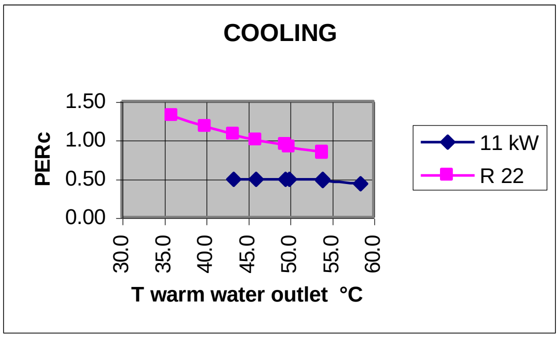

Figure. 5

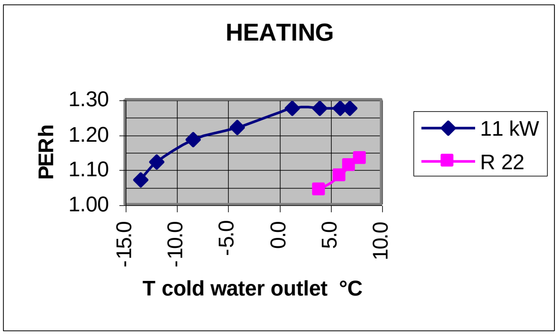

Figure. 6

The next two diagrams of figures 7 and 8 show the effective chilling and heating power delivered by the 11 kW machine also for temperatures different from the design one.

It can be seen that, due to a tuning oriented to the summer conditions, when the natural gas consumption is higher, the cooling power is closer to 13 kW instead of the expected 11 kW, while the heating power in winter conditions is about 19 kW instead of the expected 22 kW.

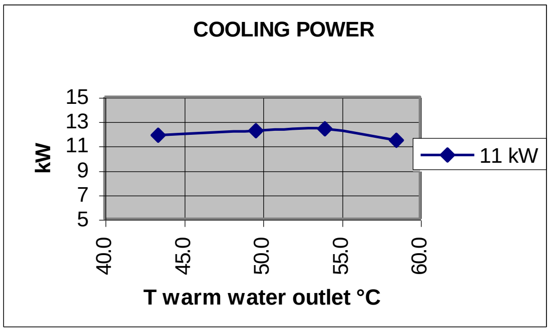

Figure. 7

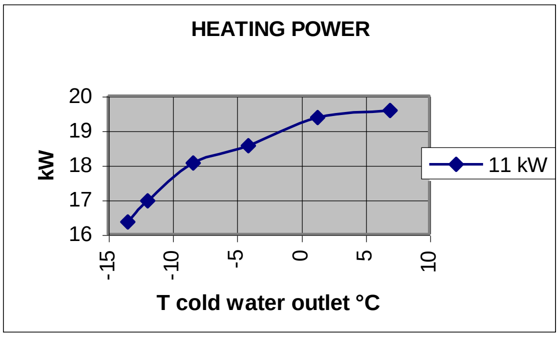

Figure. 8

The last figures 9 and 10 summarize a simulated calculation (ENEA 1998) for the TEWI (Total Equivalent Warming Impact) in order to evaluate the environmental benefit of using such a new machine compared to an Air-Air compression machine (R22), presently the most common technology for air conditioning.

The Blue (right) and red (left) histograms represent respectively cooling and heating operation.

Continuous bars: this work; Chequered bars: compression machines.

Residential: 1000 equivalents hours at full load per year for heating; 500 for cooling.

Tertiary: 1000 hours equivalents at full load per year for heating; 1000 for cooling.

Refrigerant recharges: 1 every three years.

Refrigerant losses: a coefficient equal to 0.8 is applied to the COP of compression machines.

Efficiency of transformation from fossil fuel to electricity equal to 33%.

The emission, in Kg of equivalent CO2 per kW delivered, are relative to a lifetime of ten years.

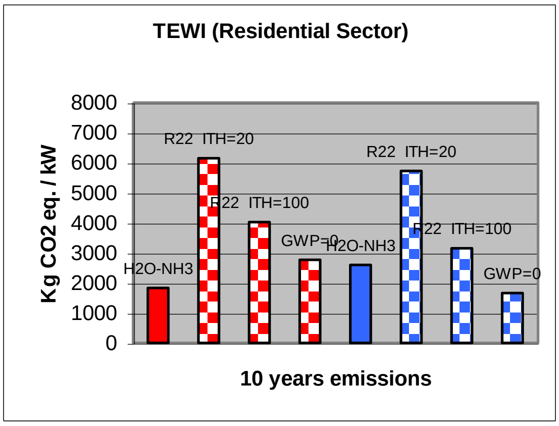

Fig. 7

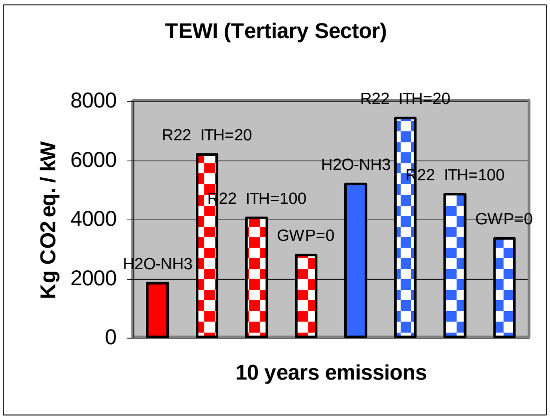

Fig.8

For the TEWI calculations (FCCC 1999) the United Nation Framework Convention for the Climate Change recommended a 100 years Integration Time Horizon (ITH).

Together with a fluid with no Global Warming Impact, like ammonia or propane, it was considered interesting to include in the simulation also the 20 years ITH , since it is closer to the deadlines of the Kyoto Protocol.

7-Future developments

The first 25 kW machine is going to be laboratory tested (March 2002).

The 11 kW machine, due to a better then expected performance, will be upgraded to 15 kW and, after an additional industrialization phase for the exchangers, will be field tested during the summer of this year.

The commercialisation of the 11 kW machine is planned for the second half of 2003.

ENEA, NET, Merloni TermoSanitari and ITALGAS started a new R&D programme, named STAR, aimed to the development of more compact and advanced machines for both residential (7 kW) and tertiary (15-30 kW) sectors.

8-Conclusions

The climate of the Mediterranean area results to be favourable to water-ammonia absorption machines with chilling and heating capabilities.

The market trend for absorption chillers is already good; nevertheless a machine capable of operating also as heat pump for space heating is still not available.

The technical-economical feasibility for this kind of technology was practically proved.

Compared to the compression cycles, the new machine shows a general performance almost insensitive with respect to the external temperatures.

The environmental impact is minimized, due to the good heating performance and, most of all, thanks to the fluids utilized, showing zero Ozone Depletion and Global Warming potentials.

Acknowledgements

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