Promotion of Eco-building Technologies, small Polygeneration and Renewable Heating & Cooling Technologies for Buildings

ProEcoPolyNet
Best practice Sheet
”Absorption chiller driven by bio-heat”

RTD Project Identification

RTD Project Name: *Absorption chiller driven by bio-heat*

Description of technology

Biomass boiler and absorption chiller for small-scale heating/cooling applications

Ab- or adsorption chillers have just been available with rather large cooling capacities, most often beyond 100 kW, which made them unsuitable for smale scale applications such as airconditioning in office or residential buildings. Only recently smaller engines with a capacity of 10-20 kW have emerged and even smaller ones (2-5 kW) are under way.

The main benefit of thermally-driven ab- or adsorption chillers is the lower electricity consumption compared to electrical compression chillers. By using renewable heat (e.g. solar heat or heat produced by a biomass boiler) the whole process is nearly CO_2 neutral.

By the end of 2006, the installation of a joint heating and cooling biomass system was completed in the Matera province, Basilicata Region, Italy. The system was installed in a 1.000 m^3 residential building that acts as a regional “Formative Centre for Bioenergy Applications”. The production of "cold" is done by a single stage lithium bromide (LiBr) absorption chiller driven by hot water produced by a biomass boiler. The biomass boiler is used for water heating, for space heating in winter and for airconditioning in summer.

The Li-Br cycle was prefered to the ammonia cycle due to the possibility of using lower process temperatures (90 C°), which can also be achieved by commercial biomass water boilers. The ammonia cycle requires diathermic oil boilers or high pressure steam with temperatures up to 300 °C.

The performance of the plant will be compared to a reference system (electrical compression chiller) in respect of economical, environmental and social aspects. Process monitoring of energy balances and biofuel costs will be carried out to evaluate the installation.

Operating principle

The absorption cycle

The absorption cycle uses a heat-driven concentration difference to move refrigerant vapors (usually water) from the evaporator to the condenser.

As shown in **Fig. 1** refrigerant (mostly water) is evaporating in the evaporator. Heat is consumed and this causes the chilling effect. The water vapor is absorbed by the absorber (concentrated LiBr solution) due to its hygroscopic characteristics. The more diluted solution is then pumped to the concentrator at a higher pressure where heat is applied (using steam or hot water) to drive off the water and thereby re-concentrate the lithium bromide. The water driven off by this heat input step is then condensed (using cooling tower water), collected and transported to the evaporator to complete the cycle. The absorption chiller must operate at very low pressures (about l/l00 th of normal atmospheric pressure) for the water to vaporize at a cold enough temperature.

The absorbent is the material that is used to maintain the concentration difference in the machine. Most commercial absorption chillers use LiBr. LiBr has a very high affinity for water, is relatively inexpensive and non-toxic. However, it can be highly corrosive and disposal is closely controlled. Water used as refrigerant of course is extremely low cost and safety simply isn't an issue.

Technical characteristics of installation

The proposed system will be constituted by three main components:

- biomass high efficiency water boiler with a thermal output capacity of 55 kW (by Froeling)
- absorption chiller with a cooling capacity of 35 kW (by Yazaki)
- cooling tower

A scheme of the installation is shown in **Fig. 2**.

The plant is supposed to operate for 2.000 hours/year during the winter season. During the summer and the intermediate seasons other 2.000 hours/year are foreseen (airconditioning and hot water production).

Location and use

This LiBr-absorption chiller in combination with a biomass boiler is intended to be used for airconditioning of residential and office buildings. In this case the chiller was installed in a residential building with a size of 1000 m^3.

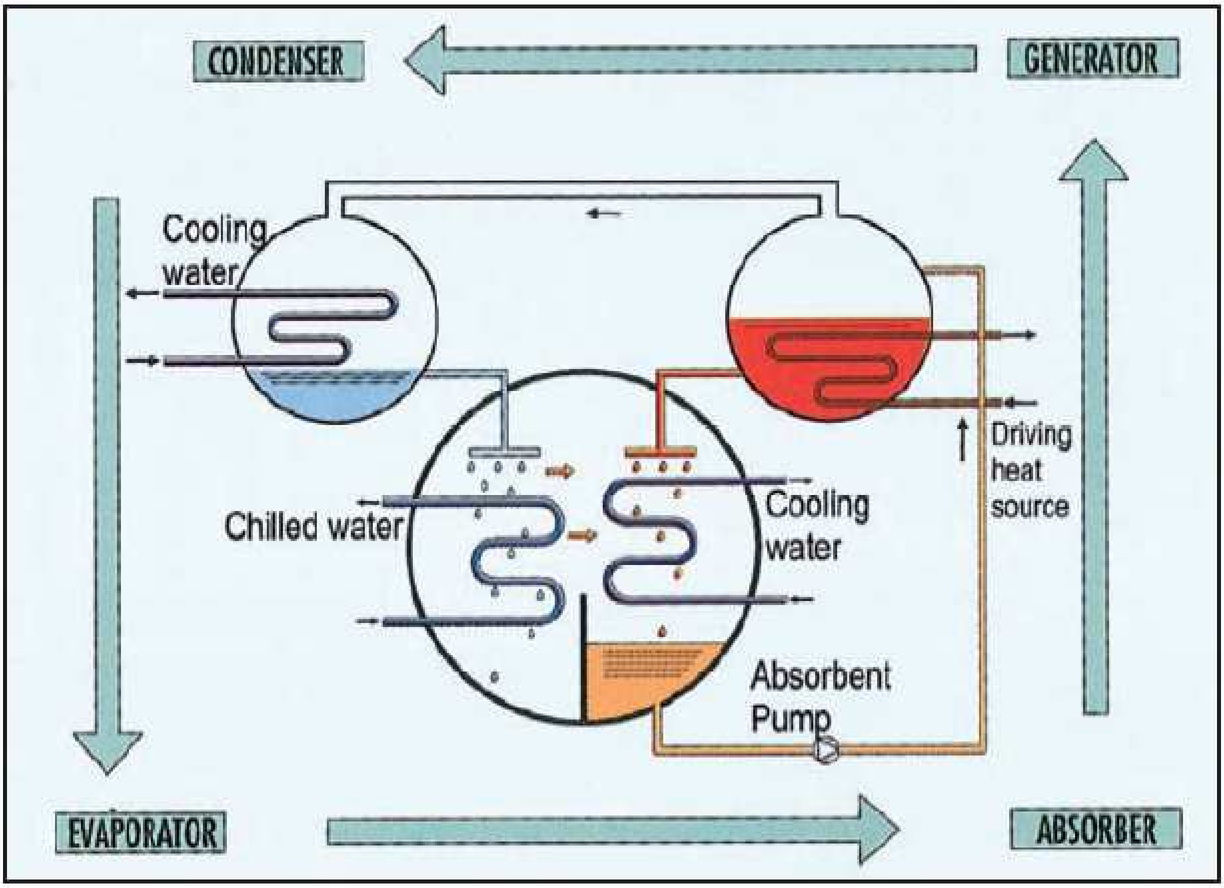

Fig. 1 ***The basic operation cycle of the single stage absorption chiller***

State of Development/Market implementation

Small scale absorption chillers driven by bio-heat, which can compete with modern electrical compression chillers, are still in the phase of field testing. Practical guidelines for the construction, design and dimensioning of such absorption chillers are still rare. A greater number of evaluated demonstration plants might help to overcome this lack of experience.

Benefits and obstacles

Benefits

- Absorption chillers provide the possibility to produce "cold" by the usage of renewable energy (biomass or solar energy).
- The electricity grids – especially in the warmer, southern parts of Europe – are not designed for peak loads nowadays encountered on hot summer days. This might results in a instable grid and even in electrical power outages. The replacement of electrically driven compression chillers by absorption chillers could reduce the huge amount of electric consumptions for air-conditioning and help to reduce the risk of a national electric power breakdown.
- Absorption chillers do not use refrigerants with ozone-depleting potential or global warming potential.

Obstacles

- The upfront investment costs for absorption chillers are still higher than for conventional electrical compression chillers. Simulations for various office buildings have shown that the upfront investment costs for absorption systems are still about 2 up to 2,5 times higher than for conventional systems. Even assuming very low fuel prices absorption chillers are mostly not competitive if no subsidies are granted.

Capital investment and maintenance costs

► *Capital investment*

Capital costs are put at € 65.000. The additional charges compared to a conventional electrical compression chiller are around € 30.000. Subsidies of € 35.000. were granted.

► *Fuel costs*

Biofuel (wood chips 35% moisture content) costs: 120 €/toe

► *Fuel consumption (estimation)*

Wood chips with a moisture content of ~ 35% are used as fuel.

Overall fuel consumption: 60 toe/year

Fuel consumption for cooling: 20 toe/year

► *Cost-Benefits features (estimation)*

Operating costs of a conventional vapour compression chiller *(reference system)*

- kWh_{el} x working hours x working factor
- Electric energy fare: 0,14 €/ kWh_{el}
- Yearly energy cost: € 7.000

Operating costs of the absorption chiller driven by biomass

- kWh_{th} x working hours x working factor
- Biomass cost: 0,02 €/kWh_{th}
- Yearly energy cost: € 1.000

Additional charges PAY- BACK time

- 6 years

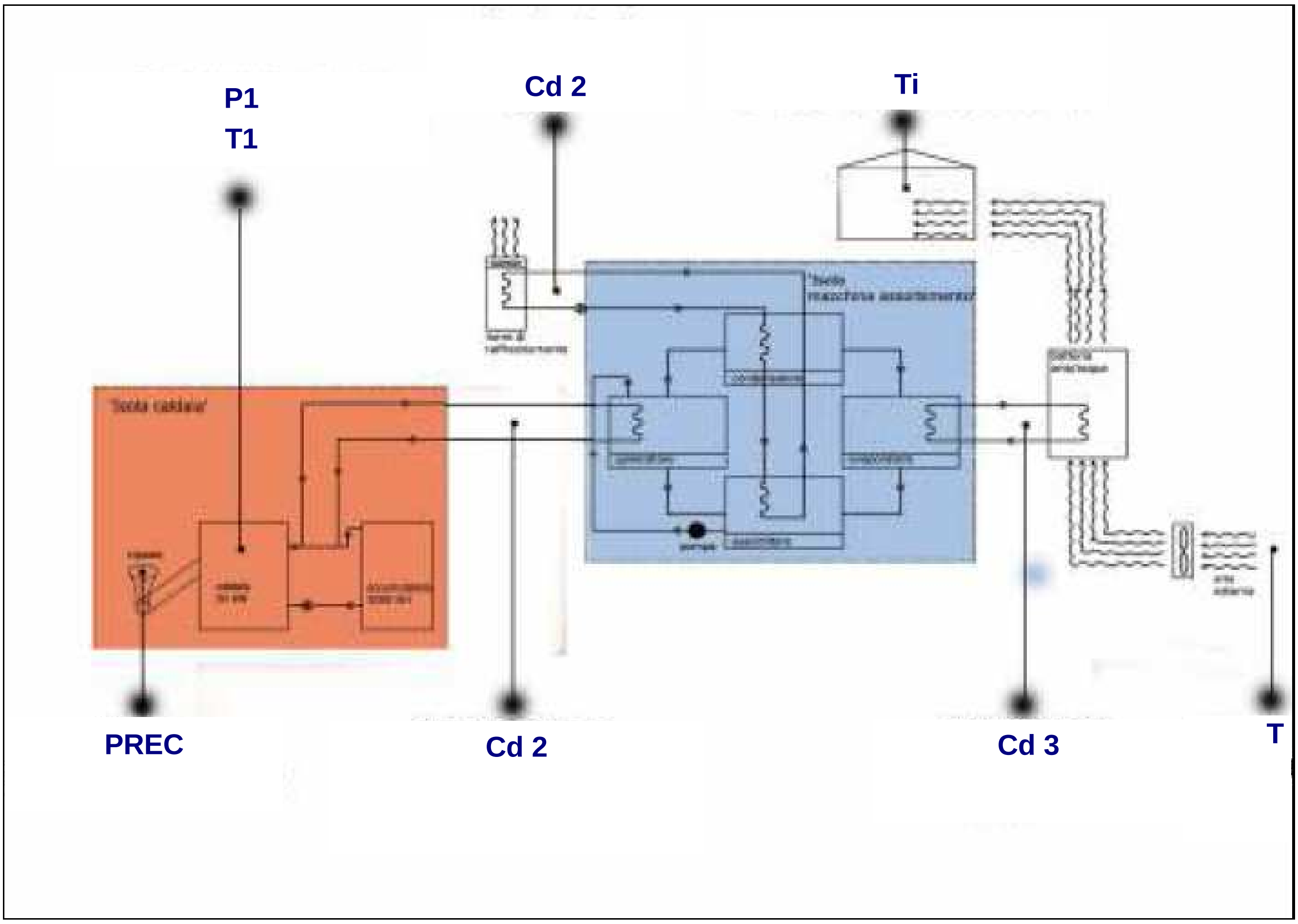

Fig. 2 *Scheme of absoprtion chiller driven by bio-heat*

(**PREC**: Biomass feed measurement, **Cd 1**: Boiler heat production, **Cd 2**: Cooling tower heat loss, **Cd 3**: Usable heat/cold, **T**: Outside temperature, **Ti**: internal temperature, **T1**: flue gas temperature, **P1**: flue gas flow)

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