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

ProEcoPolyNet
Best practice Sheet

Absorption Heat Pump
utilizing waste heat of a composting plant

RTD Project Identification

Absorptionswärmepumpe Kompostwerk VIVO

DBU: Deutsche Bundesstiftung Umwelt, Industrial Contract

Description of technology

At a municipal composting plant, waste heat is generated at a temperature level around 45°C (113°F). Previously, this waste heat had to be rejected to the ambient by means of a cooling tower so far. A direct-fired single-stage absorption heat pump lifts the waste heat to a temperature level of 82°C (180°F) enabling its utilization in the local heating network of a commercial area. Single-stage heat pumps reach thermal efficiencies around 1.7, double-stage cycles reach efficiencies above 2.0; i.e. about 40-50% of the supplied useful heat originates from the ambient heat source instead of the driving heat. For direct fired machines however also the boiler efficiency has to be taken into account to determine the primary energy ratio PER.

Operating principle

At a municipal waste processing plant in southern Germany a single-stage absorption heat pump has been installed for recovery of the waste heat rejected by the biological, aerobe rotting process of the organic waste. During the rotting process the organic material is moved in about ten steps from heap to heap across the composting plant, starting in “intensive” compost heaps containing the most recent base material with temperatures of the rotting process about 75°C. After about 40 days the rotting process ends at approximately 30°C and the compost leaves the plant sanitized and well decomposed; hence, it can be applied for agricultural uses. During the rotting process the compost heaps are forced-air ventilated in order to maintain an appropriate oxygen supply. The heat content of the warm moist air from the first three heaps is transferred to a cold water loop and serves for heat input to the specially designed absorption heat pump.

Due to the intermittent processes of forced-air ventilation and moving of the compost heaps, the exhaust air temperature and the heat load on the cold water loop show significant variations over time. Thus, a chilled water buffer storage with a volume of 3,500 L has been integrated in order to maintain a constant temperature level of the cold water loop with supply/return temperature 34/42°C, serving for heat input into the evaporator of the heat pump. The heat pump provides a constant outlet temperature of the heating water loop of 82°C after passing absorber and condenser of the heat pump irrespective of the current operating condition. In order to achieve the large temperature lift from heat source to useful heat of about 50°C the heat pump is equipped with a gas-fired generator. The gas burner capacity is modulated from 325 to 600 kW, depending on the operating condition of the heat pump. The heat pump has been designed for a cycle COP about 1.6 at 50% part load, increasing up to 1.65 at full load. Taking into account a burner efficiency about 88% in part load and about 85% in full load a PER of about 1.45 is accomplished.

Technical characteristics of installation

- *Type: gas-fired Absorption Heat Pump*
- *Electrical output capacity (kW): none*
- *Thermal output capacity (kW) 600 kW*
- *Thermal Input capacity (kW) 410 kW*
- *Cooling to heat ration, thermal COP heat pump (regarded as a chiller) 0,65*
- *Electrical efficiency (%)*
- *Thermal efficiency (%) 145% (PER)*
- *Total efficiency (%) 145%*
- *Marginal electrical efficiency (%)*
- *Power to heat ratio*
- *Noise emissions (dB)*
- *Weight (kg) 8000*

Location and use

► *Private Buildings*

► *Residential Buildings*

► *Commercial Buildings: Heat supply to district heating network in a commercial area.*

► *Public Buildings*

► *Others*

Capital investment and maintenance costs

► *Capital investment*

Cost of unit (€) 115.000 Euro

Specific cost of unit (€/kWe)

Installation cost (€) 99.000 Euro

Total Cost (€) 216.000 Euro

► *Avoided capital investment if any*

Avoided Specific cost (€/kWe)

Avoided Installation cost (€)

Value of avoided investment if any(€)

► *Total capital investment*

Total capital investment (€) 216.000 Euro

Total capital investment (€/kWe)

► *Maintenance*

Specific maintenance costs (€c/kWhe)

Total maintenance costs (€/a) 6.000 Euro

State of Development/Market implementation

► *Prototype*

► *Field tested*

► *Serial production: Heat Pump based on conventional Water/LiBr Absorption Technology. Thermal design specifically adapted to given requirements on site (temperatures, flow rates).*

► *Full market implementation*

► *Etc.:*

Operational data

► *Average hours of operation (h/a) 2900 h/a*

► *Fuel input (kWh/a) 1.215.300 kWh/a*

► *Electricity output (kWe/a)*

► *Heat output (kWh/a) 1.750.000 kWh/a*

► *Cooling output (kWe/a)*

► *Electricity self-consumption (%) <1%*

► *Electricity self-consumption (kWh/a)*

► Electricity exported to grid (kWh/a)

CO_2 and primary energy savings

Fuel (kg/kWh) 0,69 kWh fuel/kWh useful heat output

CO_2 emission factor (kg/a)

CO_2 emissions (kg/a) 146.000 kg/a saved. i.e. 38% emissions saving versus conventional reference (gas boiler)

Benefits and obstacles

Absorption heat pumps allow for a large energy saving potential. In a base-load design with peak energy supply by conventional boilers, long annual utilization is reached. Payback periods below 5 years are realistic.

As known from applications with mechanical vapour compression heat pumps, a careful system design with special regard to the temperature levels of the external heat carriers (heat source, useful heat) has to be carried out.

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