CADDET energy efficiency IEA OECD

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Buildings
Industrial boilers &
water hesating

Ultra-high Efficiency Direct Contact Water Heater

View of the 1.3 MW direct contact heat exchanger water heater.

Highlights

- Eliminates heat exchange surface fouling
- Constant thermal efficiency of 96% for varying temperatures
- Low NOx and CO_2 emissions
- 5% energy savings over a high-efficiency hot water boiler

Summary

The direct contact heat exchanger water heater, installed by Sofame Technologies Inc at the Neufchatel Professional Formation Centre in Québec, represents an extremely high-efficiency method for heating water for commercial space heating applications. The system is equipped with a water vapour pump (WVP) which returns lost energy to the system, resulting in a fairly constant 96% overall thermal efficiency for varying return fluid temperatures and operating conditions, as well as very low greenhouse gas emissions. This makes the system particularly attractive for closed-loop systems with high return temperatures.

Aim of the Project

Direct contact heat exchanger technology is potentially more efficient than conventional counter-current heat exchange technology because it eliminates the performance reductions caused by fouling of the heat exchange surfaces and the associated energy losses. However, efficiency can be greatly reduced by high return fluid temperatures. The water vapour pump (WVP) developed by Sofame Technologies Inc compensates for this by removing the energy still in the outlet gases and returning it to the system, thus increasing efficiency.

In order to demonstrate a full-scale application of the system, a 1.3 MW unit (Sofame produces a range of units from 300 kW to 15 MW) was installed at Neufchatel Professional Formation Centre. The building, built in 1998, was selected as a good example of a high-temperature, closed-loop space heating application for testing the technology.

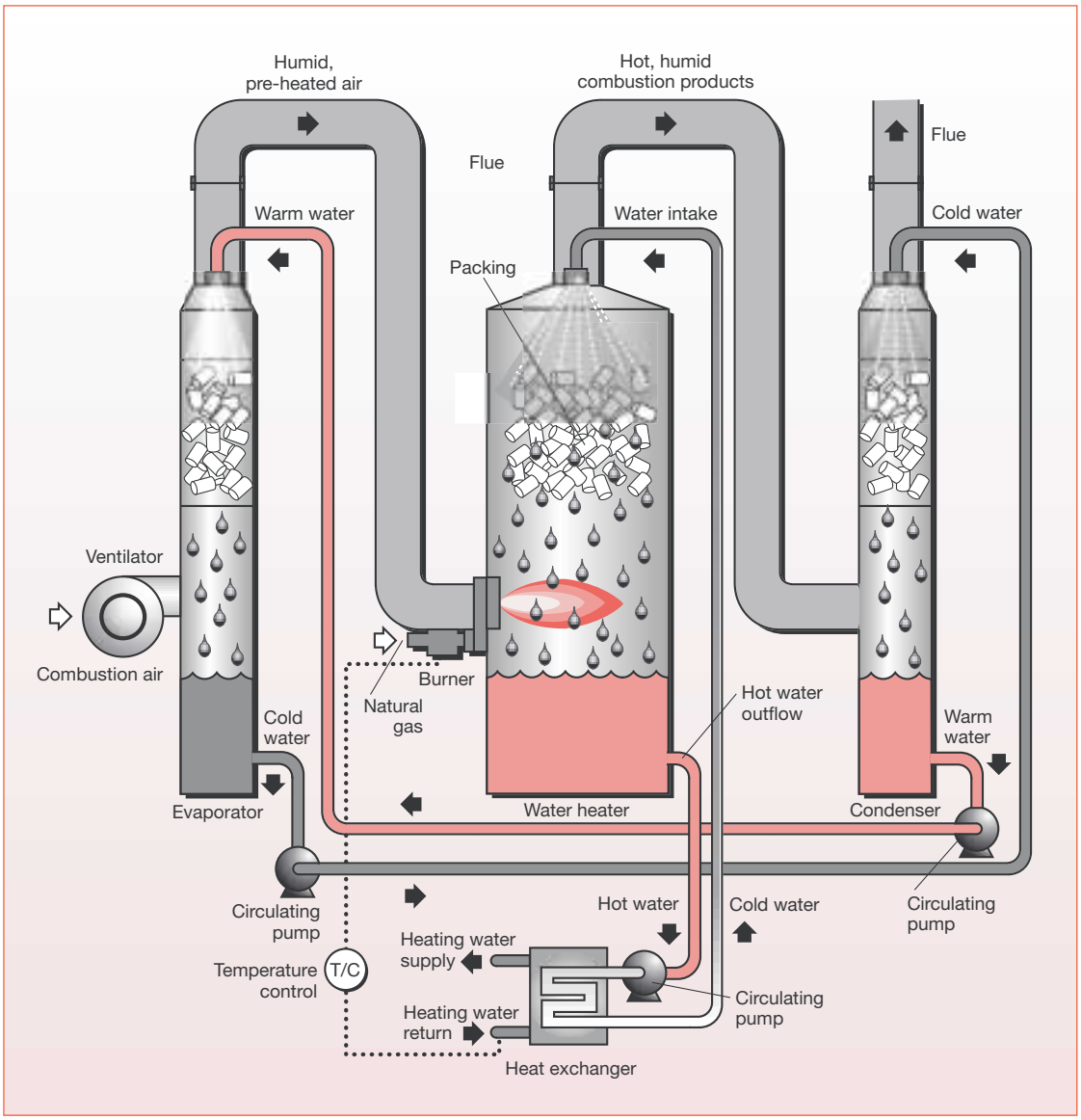

Figure 1: Schematic diagram of the direct contact heat exchanger system.

The Principle

The direct contact heat exchanger used by Sofame relies on the direct contact heat and mass transfer between the hot combustion gases and the water to be heated. The combustion gases rise along the vertical column from the natural gas burner as the water descends, picking up heat energy from the gases. Stainless-steel packing in the counter-current heat exchanger increases the contact area and slows the flow, providing improved exchange of energy. A schematic diagram of the system is shown in Figure 1.

This technology has several advantages:

- ultra-high efficiency;
- use of a clean fuel (natural gas);
- high heat transfer rate from direct contact;
- elimination of heat transfer surface fouling problems;
- condensing mode operation;
- non-pressurised equipment (simpler and safer maintenance and operation);
- ease of manufacturing of the equipment.

A problem inherent in the counter-current direct contact water heater is the limit on efficiency related to the inlet fluid temperature. Since the lowest temperature the exhaust gases can reach is that of the inlet fluid, a high inlet fluid temperature results in a lower efficiency and evaporation of the water to be heated. Sofame developed a solution in the form of a WVP which effectively maintains a constant efficiency over a range of operating temperatures. The WVP consists of a condenser and an evaporator, both of which are direct contact vertical column designs like the water heater. The condenser removes sensible and latent heat from the hot exhaust gases and sends it to the evaporator, which returns it to the system by preheating and humidifying the combustion air.

The Situation

A 1.3 MW "ultra-high efficiency" unit was installed at the Neufchatel Professional Formation Centre to satisfy the space heating needs of the building and evaluate the effectiveness of the system in an application with a high return fluid temperature. The equipment heats about 595 litres/minute of primary water from about 50°C-60°C during the heating season. This heat is transferred to the building's hydronic loop through a plate heat exchanger that has an efficiency close to 100%.

Throughout the heating season the unit global efficiency, based on the highest heating value of natural gas, remained between 94% and 97%. As the return water temperature rises, the WVP becomes more effective, compensating for the reduced efficiency of the water heater. The system is therefore able to maintain optimal operating conditions and efficiency despite variations in temperature throughout the heating season. The resulting saving in energy reached 1.4 TJ/year.

At the end of the 1999 heating season, the burner capacity of the water heater was reduced from 1.3 to 0.9 MW in order to decrease the unit cycling frequency. The unit runs at high capacity and stops rarely during periods of cold weather; during milder weather and at night and weekends, the system operates at lower capacities to save energy.

The Environment

When compared to a medium-to-low efficiency hot water boiler (75% efficiency), the new system cuts carbon dioxide (CO_2) emissions by 21%. NOx emissions are low due to the effects of the WVP (8-11 ppm at 3% excess air). However, at the operating conditions that produce the lowest NOx emission levels, CO emissions are rather high. Lowering the excess air in the burner reduces the CO emissions, but increases the NOx levels. The operator must, therefore, find a point of compromise where both emissions levels are satisfactory.

The Company

Sofame Technologies Inc, with its headquarters in Montréal, Québec, builds high-efficiency water heaters for commercial and industrial applications, and specialises in the direct

contact technology which it pioneered. The company builds each unit to the specifications required for the client's application.

Economics

The installed cost of a 1.3 MW system is estimated at CAD 90,000 (where CAD is the Canadian dollar). When replacing a seasonal efficiency boiler system, which has an estimated installed cost of CAD 52,000, for a space heating application with a 50°C return water temperature, the simple payback period is about four years. This compares favourably with the alternative of installing a high-efficiency hot water boiler with a cost of CAD 110,000 and a simple payback period of seven years.

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International Energy Agency
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CADDET
CADDET was set up in 1988 as an IEA Centre for the Analysis and Dissemination of Demonstrated Energy Technologies. Today, there are two CADDET programmes; one is for energy-efficient technologies and the other for renewable energy technologies. The CADDET Centre co-operates with member countries in the exchange of high-quality information on energy technologies.

See the whole range of CADDET Energy Efficiency projects on www.caddet-ee.org