Heat recovery from polluted extraction systems, without pre-filtration or maintenance

Problem definition

Heat recovery and the use of the recovered energy from polluted extract systems has historically been linked to decreasing efficiency and very high maintenance costs.

Soot, grease, lint, dust and other particles clog heat exchangers and cause downtime and reducing performance over time and while conventional filter technologies have been deployed to try to 'clean' the air from particles, often the technologies are both costly and, in almost all cases, unable to remove enough of the particles from the air leading to clogging of the systems, reduced performance and eventual nonoperation of the extract system.

Because of these historical issues, most sites with process ventilation today operate without any equipment for energy recovery deployed. The result is that an enormous amount of process heat, from operations like restaurants, bakeries, industrial laundries, and wood industries, is currently wasted.

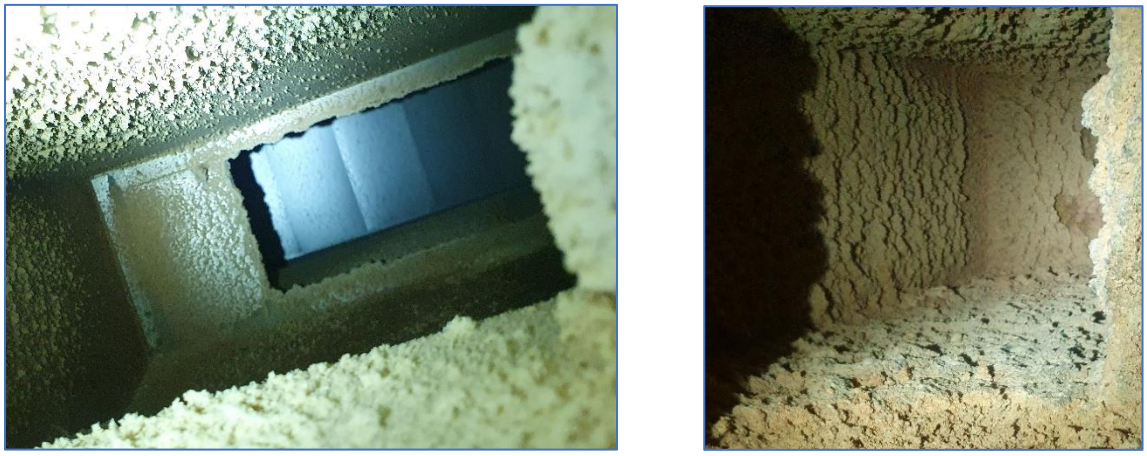

Figure 1. The interior of a grease duct from a restaurant kitchen

Question

Is it possible to achieve robust energy recovery from polluted exhaust air, without pre-filtration and excessive maintenance and still avoid:

- Increased pressure drop and subsequent increase in fan power due to build-up of particles in the heat exchanger?
- Downtime due to build-up of particles in the heat exchanger?
- Decreased power output from the heat exchange system over time due to build-up of particles in the heat exchanger?

System: Lepido

Lepido is an Innovated & Made in Sweden air-to-fluid heat exchanger, specially designed to be deployed in polluted air streams. It is developed for mounting in the duct, without any requirement for pre-filtration.

Contrary to a standard heat exchanger, where the natural forces constantly work against keeping the unit clean, the Lepido interior is designed to work with the natural forces. It involves a geometry that is fin-less design and allows for more spacing than a traditional heat exchanger.

To accommodate the patented geometric design, which consists of coils only – no flat surfaces, no fins – Lepido is deeper/longer than a traditional heat exchanger.

Heat transfer surface in a Lepido is still comparative to a standard heat exchanger with fins.

Figure 2. Lepido exterior and cross-section of housing / coils

Method

The Lepido was installed at a Burger King restaurant in Malmö, Sweden, in the autumn of 2020.

The purpose was to explore the resilience of the system in this environment without the installation of pre-filtration before the heat recovery unit and without ongoing maintenance. The test has now been active for 22 months. (After discussions with local authorities, it was agreed that the Lepido could be excluded from the mandatory duct cleaning cycles during the test).

Project data

Site: Burger King Malmoe/Sweden
Operating hours: 16h/day
Air flow exhaust air: 1,02m3 /s
Air flow make-up air: 2,0m3 /s
Temperature exhaust air: 34°C
Temperature set-point make-up air: 16°C
Lepido unit: L12-14.30

Measure points

The site control system has measured and logged the following data points once every minute during the 22-month test period:

Temperature Outside air (GT-UTE)
Temperature Make-up air (GT-TILL)
Temperature and relative humidity exhaust air, before Lepido (GT-FL/GH-FL)
Temperature exhaust air, after Lepido (GT-AL)
Temperature coolant, inlet (GT-KBT)

Fluid flow, Circulation Pump (CP1)
Temperature coolant, return (GT-KBR)
Static pressure drop Exhaust air, before Lepido (GP-AL)
Static pressure drop Exhaust air, after Lepido (GP-FL)
Output signal actuator (SV1)

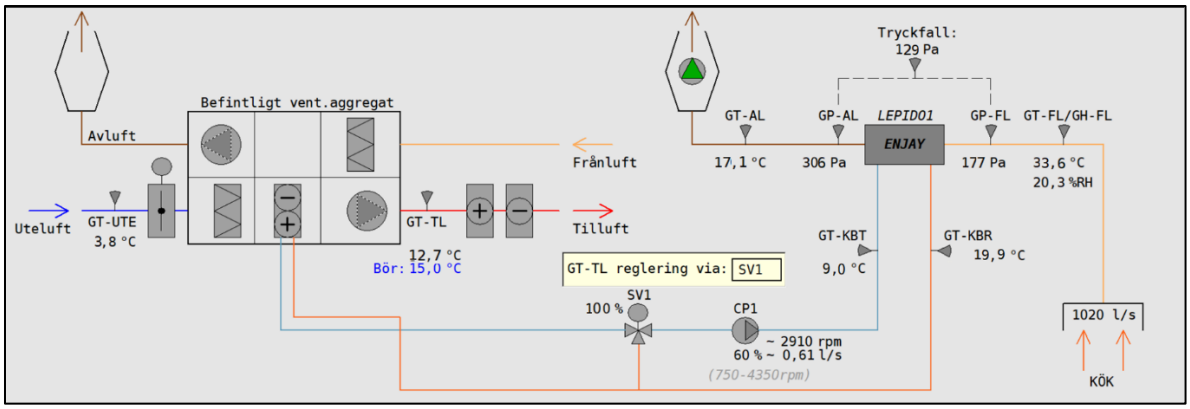

Figure 3. Testrig system overview, indicating measure points

Air flows were not continuously monitored. Exhaust and Make-up air flows measured at the start and at intervals of 3 months during the test period to ensure they remained constant.

The air handling unit is pressure controlled, providing a constant pressure value in both the make-up and the exhaust duct. This control method is deployed to compensate for any derating of the filters on the outside air / make-up air side of the unit.

The exhaust air rate is regulated with fixed output signal via frequency converter while the compensation of increased pressure drop was not taken care of, despite this, the measured air flow during the full 22 months does not vary outside of the measuring tool's tolerances of +/- 10%.

Measurements made with conventional methods, both static and dynamic pressure sets and with hot wire anemometer. Existent heat recovery in air handling unit is by-passed during the duration of the test, to isolate measurements to only the Lepido system.

The control system creates trends for pressures and temperatures based on minute-values and calculates efficiency and performance over time. The trends would reflect any downtime or loss of functionality caused.

Results

22 months of continuous operation without pre-filtration or ongoing maintenance, results in a limited build-up on the coil can be seen in Figure 4. Though visually obvious, the build-up has very limited detrimental effect on the outputs measured by the control system.

Impact on operation (Fig. 5)

Figure 4. Photo of the inlet side of the exhaust air into the Lepido after 22 months of operation without pre-filtration or ongoing maintenance

Number of reported malfunctions	**0**
Increase in pressure drop exhaust air due to build-up	**about 50 Pa (25 Pa/year)**

Impact on energy recovery (Fig. 6)

Change temperature efficiency	**-1%**
energy recovery	**86 000 kWh / year**

*The energy recovery is calculated using the project data for temperatures, air flows and registered operating hours

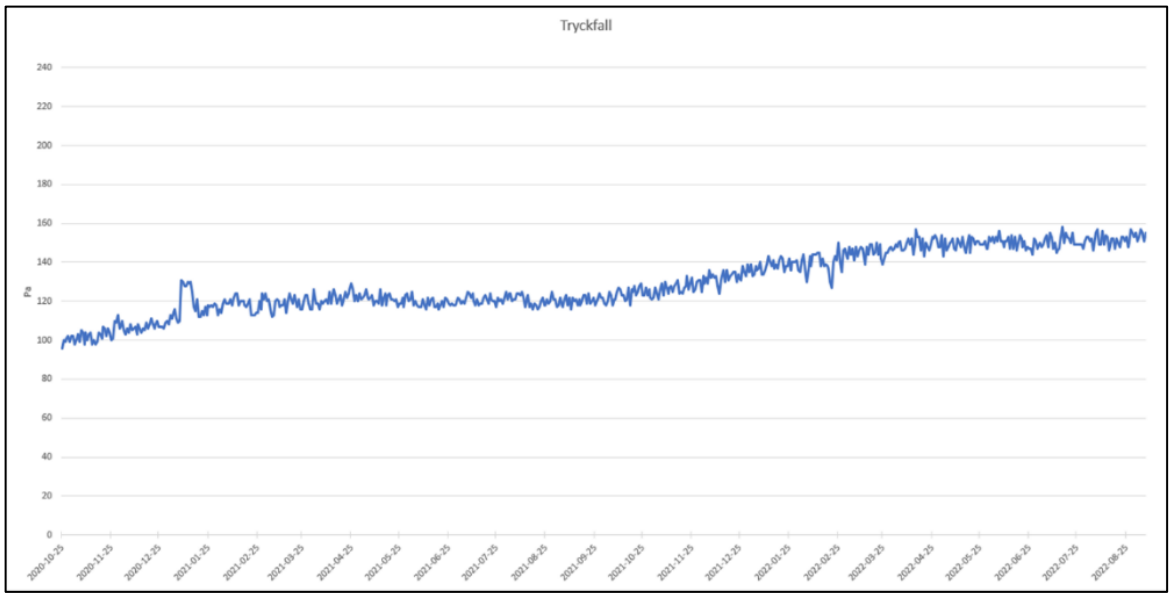

Figure 5. Graph measured increase in static air pressure over 22 months (GP-AL)-(GP-FL)

Conclusion

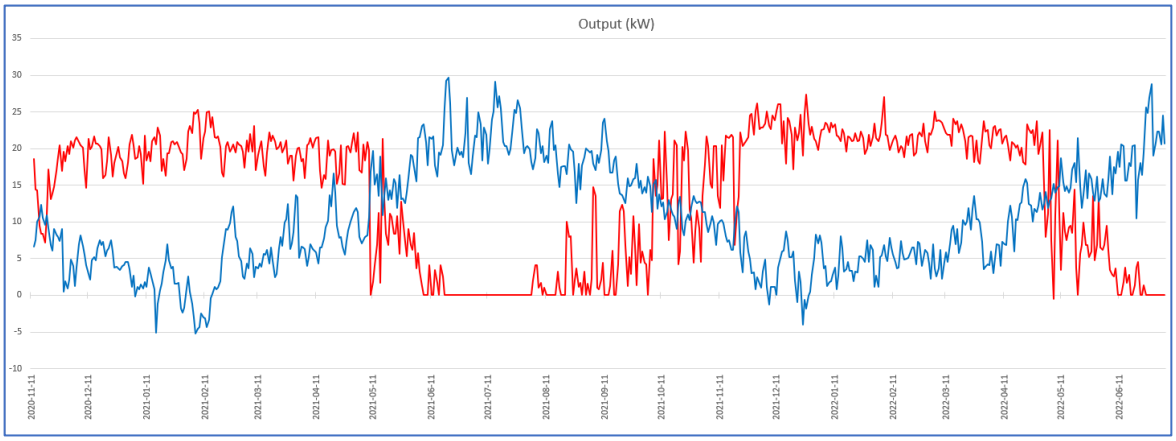

Figure 6. Graph energy recovery (red) in comparison to outside air temperature (blue)

Lepido has, without pre-filtration and ongoing maintenance, delivered stable energy recovery, without causing any downtime or malfunctions. The test provideds evidence that it is possible to achieve robust energy recovery from polluted air without any pre-filtration, without ongoing maintenance and without risk of downtime or malfunctions. However, the test is to prove that the performance of the system is able to withstand the extreem conditions, it would be recommended to have the ductwork and heat recovery unit cleaned in accordamnce with local recommendations. The Lepido system opens up for cost effective energy recovery in a long row of process ventilation applications, where it used to be impossible because of the pollutants.