HEAT RECOVERY FOR VENTILATION AND PROCESS

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Recovery can be done on the air side for ventilation, or from flue stacks. It is mostly a reversible process, where heat can be taken from the hot exhaust air to be added to the cold fresh air, or where the heat from the fresh air is moved to the exhaust air, so cooling the fresh air.

For mechanical cooling, we can recover heat removed from the space or process. This heat is removed either by chilled water or refrigerant. In most of these cases, all or some of the heat is recovered from the refrigerant.
Air to air recovery also known as recuperation.

As a reversible process, the ventilation heat recovery is more like energy exchange.

The fresh air can be heated or cooled by the exhaust air conditions. The expense of such a system is worth while for very large systems, or systems with full or high fresh air content. From this the recuperator story.

The biggest advantage of the recovery is the reduction of peak heating and cooling loads, as well as the associated reduced central plant size and power consumption.
I think there is 5 different genres of the ventilation recovery system.

The plate exchanger, the run around coil, the enthalpy wheel, heat pipes and refrigerated systems. Of this 5 systems, the heat pipe is not reversible, and can therefore be discussed over a class of cooldrink later. It is very handy in really cold winters, but not much use in mild climates, in my opinion.
We have prepared a comparison between the plates, run around and the enthalpy wheel. The chosen conditions are seal level, 2000 l/s and 32 / 22 °C ambient conditions. For the sake of brevity and relevance, we show most of the comparisons for summer conditions, while the winter performance is shown in a table later on. The room is estimated at 22°C / 50% RH, a consultants favourite condition.
In this type of recuperate, the air flows with perpendicular in adjacent channels.

The device is made from stainless steel, or paper. Normally it is a sensible heat exchanger, but permeable versions are available. There are also replaceable paper cartridge types, normally used in more hostile environments as cleaning of the plates is a time consuming task. Unless there is a leak in the plates, the air streams does not mix.
Looking at our comparison conditions, this device will have a leaving air condition of 24.7°C, and 64.2% RH, and we recover 18.4 kW
Run around coils are 2 coils, each in a air stream. The heat is moved from the warmer stream to the colder stream. In itself, it is not the most efficient system, but it has some advantages.

The air streams can be remote, and the chances of air leakage is also, well, remote. But the system is very patient for additional refinements.
We can add evaporative cooling to the exhaust air in summer to reduce the dry bulb temperature, and thus increase the sensible heat transfer window.

Or we can add some mechanical cooling to the system to increase the capacity of the cooling coil, with a large delta T system.

For the comparison, however, we have used the plane jane version of the system.
We have 17.2 kW of heat transfer for our system, with air leaving at 26.3 C and 58.5% RH
The hygroscopic wheel transfers both temperature and moisture. The aluminium plate from which the wheel is rolled can be treated with silica gel to become the desiccant wheel.

It is also possible to treat the aluminium so that the surface becomes microscopically rough, and thereby become hygroscopic to move the moisture.

A proper recovery system with such a wheel will have a section where the exhaust air in the wheel is flushed to the outside, and thus no carry over should take place, but of the 3 systems, this one has the highest risk of carry over.
With this wheel in our little system, we recover a total of 39.08 kW, with a leaving condition of 23.7°C and 50.9% RH
From here it can be seen that the winter performance is better than the summer performance. And that a significant amount of moisture is also recovered, of the 9 grams required.

It also clear how much the complete building can save in maximum cooling demand, the actual % saving will depend on the balance of the load, other than the fresh air load.
I have noticed lately that there are units on the market that uses a refrigeration system as a full fresh air unit mode of cooling. As the source side is always in the exhaust air stream, the efficiency of the complete system should be very good. And it eliminates the need for additional cooling and heating coils. With variable speed compressors and supply air temperature control, this is an expensive unit, but I have not seen much pricing in this regard.
Do we have any discussion from the floor regarding recuperators.
So now we can look at various types of recovery for mechanical cooling. I have based my diagrams on chillers, but it is reasonably similar for other equipment.
HEAT RECOVERY

Heat Recovery from refrigeration equipment

Partial recovery
Total Recovery
Multipurpose machines
This is a simple diagram for a refrigeration circuit with partial heat recovery, in this case a de superheater. This means that the heat recovered is from the sensible cooling of the refrigerant when it leaves the compressor, before it enters the condenser where the latent process of condensation takes place. Typically, the full load efficiency of a air cooled chiller increases with the addition of a desuper heater.

The capacity of the desuper heater decrease as the outside temperature, and therefore the head pressure, decrease.
From this table we can see that efficiency of the chiller increase with the de superheater. If any more heat than the de superheat is required, and taken from the chiller in this fashion, then the overall efficiency will fall as the head pressure is kept constant to allow for heat recovery. This should become more clear in a few moments.
When we look at this diagram, we see a chiller that can supply all available heat to the water cooled condenser, or dump all the heat to atmosphere. This allows the chiller to operate at lower efficiency when only some heat recovery is required, by cycling between recovery and cooling only. It is possible to built a chiller with full recovery with the 2 condensers in series, and thus extract the exact amount of heat at any time, but then the chiller has to operate at a high head situation all the time while in recovery. Let us look at some efficiencies.
Using a machine with the condensers in parallel, allows us to run the machine on a basis that 50% heating requirement is the same as 100% heating for 50% of the time. While this requires some storage, changing between the condensers every 5 minutes will lead to a reasonable accurate leaving hot water temperature. This is possible because there are normally 2 circuits in such a machine.

So we can then operate at a EER of 4.64 for some of the time, and at 2.51 for the rest. The power saving for this compared with a series arrangement is clear.

The equivalent for a water cooled machine is a double bundle condenser, where you have 2 tube bundles in a single condenser shell. Some additional controls are required to ensure that the machine changes over smoothly.

The disadvantage of this system is that you can only recover the amount of heat available from the cooling process. So, for space heating as an example, we would need a machine that can do more heating than cooling.
This heart lung machine lookalike is a diagram for a multi purpose machine, or Energy Raiser, or Integra. It can operate in cooling only mode, heating only mode or in heating and cooling in any mixture. In this case, it has a dedicated condenser, for water heating, and a dedicated evaporator for generating chilled water. The refrigerant to air coil can be either a evap or a condenser. In fact, I have a movie and some interactive presentations for this:
MULTI PURPOSE

• HEATING AND COOLING

• ALSO AVAILABLE AS 6 PIPE UNIT
  • ADDITIONAL HEATPUMP
  • USING HOT WATER FOR EVAPORATOR
  • UP TO 70º LEAVING WATER

• THIS MAKES IT POSSIBLE TO HAVE DOMESTIC HOT WATER AND SPACE HEATING HOT WATER

• DE SUPERHEATERS CAN ALSO BE INSTALLED
SUMMARY

- Air to air recovery to reduce central plant size, maximum demand and power consumed
- Recovery from refrigeration circuit to generate hot water at little extra cost
- Various systems are available to suit the project