Heat exchangers

Operating principle of the recuperator unit

The main task of the recuperator is to expel foul air and supply fresh air with specific parameters - temperature, moisture, efficiency.

Warm air supplied from the outside by an intake ventilator passes through filters, where dirt, dust and pollen is removed, afterwards it is pumped into the heat exchanger. At the same time, foul, cold air from the room is taken in by the exhaust ventilator and also lead to the heat exchanger. The two air masses are pumped through the heat exchanger.

Thermodynamic exchange takes place in the heat exchanger. In our case, the cold from the outgoing air is transferred to the supplied air flowing from the outside. Next, the cooled air is pumped into the room, and foul air is expelled outside. It is a process of recovering heat from the expelled air.

In wintertime, the process is as follows: cool air taken from the outside is cooled by the foul air expelled from the interior. Thermal efficiency of the entire process depends, among others, on the type of exchanger and the materials which it is made of.

Heat exchangers

The most important component of the recuperator unit is the heat exchanger. Presently, there are many different types of recuperator units with different structure, air flow direction, degree of recovery and application. HRU-ECCO and HRU-ERGO recuperator units by Alnor are fitted with, respectively, a cellulose cross-flow exchanger and a countercurrent exchanger.

In the cross-flow exchanger, air flows converge at the 90 degrees angle (illus. 2) See illus. 1 for an image of such an exchanger. Cross-flow exchanger utilizes a system of perpendicular plate ducts. Heat exchange takes place at the contact point of these ducts. Supplied and expelled air flows mix.
The air distribution diagram is as follows (illus. 2):

\[ \Delta T_k = \frac{21 - 10}{21} \cdot 100\% \approx 52\% \]

**Illus. 1 HRE-ECCO cross-flow heat exchanger**

**Illus. 2 Cross-flow exchanger diagram**

- **T_{OA}** – świeże powietrze zaciągane z zewnątrz
- **T_{RA}** – zużyte powietrze wywiewane z pomieszczeń
- **T_{EA}** – zużyte powietrze wyrzucone na zewnątrz
- **T_{SA}** – świeże powietrze nawiewane do pomieszczeń

\[ +21^\circ C \]

\[ +12^\circ C \]

\[ +10^\circ C \]

\[ -1^\circ C \]
Temperature recovery process in a cross-flow exchanger is shown on the diagram below (illus. 3)

**Illus. 3 Heat recovery diagram for the cross-flow exchanger**

Advantages of HRE-ECCO Alnor recuperators fitted with a cross-flow exchanger:
- simple construction
- no moving parts
- max heat recovery 75%
- possibility to improve recovery efficiency by lateral connection

In countercurrent exchangers, air flows laterally, in opposite directions (illus. 5) The small ducts through which the air flows are triangular in section. In such a solution, contact points are larger, which means recovery efficiency is greater. See illus. 4 below for an image of an counter-current exchanger.

**Illus. 4 HRE-ERGO countercurrent exchanger**
Rys. 5 Counter-current heat exchanger diagram

Based on the air distribution diagram (illus. 4) we get:

\[ \Delta T_p = \frac{21 - 5}{21} \cdot 100\% \approx 76\% \]

Temperature recovery process in a cross-flow exchanger is shown on the diagram below (illus. 6)

Illus. 6 Heat recovery diagram for the countercurrent exchanger is as follows
Advantages of HRE-ERGO Alnor recuperators fitted with a countercurrent exchanger:
- simple construction
- no moving parts
- max heat recovery 80%
- no frosting of the installation
- no current obstruction

An important factor is that both the countercurrent and cross-flow exchangers are made of a material with an antibacterial coating, which kills various types of bacteria and prevents the spread of various fungi in the exchanger. The antibacterial coating is also resistant to abrasion. This means it’s not worn during cleaning. The coating is bactericidal, including the following strains: E coli 8099, Staphylococcus aureus ATCC6538, Klebsiella pneumoniae ATCC4352, Candida albicans ATCC10231,

**Moisture recovery**

HRE-ECCO and HRE-ERGO exchangers are fitted with a moisture recovery function. This means that Alnor recuperator exchangers can be used to recover both heat and moisture from the expelled air, and subsequently transfer the moisture to the air supplied to the room. This is especially useful when the air gets dry, especially when being heated in wintertime.

Moisture recovery process happens in the recuperator’s exchanger. The exchanger allows to directly transfer water molecules including the energy they contain. Condensation does not happen in this case, which mean there is no energy lost as steam. This is one of the factors for the high efficiency factor of the countercurrent recuperators.

The process described above is possible thanks to the special construction of the exchanger unit. The exchange is made of a special 45µm paper, which is highly resistant to tear and aging. The entire secret lies in the thickness and structure of the paper used in the exchanger. The mesh size of the paper is 0,3nm. Dirt particles size is larger than 0,3nm, while water molecules are 0,288 nm in diameter. This means that only moisture is able to permeate through the mesh in the exchanger, and can be transferred to the air supplied into the room (illus. 6 and tab. 1). Despite such construction, the exchanger has very high tightness. Heat exchanger which also allows for moisture recovery is also known as an enthalpic exchanger.

*Illus. 6 Structure of the material which the exchanger is made of and moisture recovery process diagram*
In summer, the supplied air is cooled and its moisture is decreased. In winter, the supplied air is heated and its moisture increases. To sum up, Alnor recuperators are able to adjust the moisture of the air supplied to the room.

**Summary**

To sum up, HRE-ECCO and HRE-ERGO recuperators offer:

- high heat recovery efficiency, with 1 : 1 ratio of supply and exhaust air
- resistance to frost, which means the heat exchanger does not get blocked by ice in negative temperatures, it doesn’t use electric air heaters which would consume energy
- air-tightness of the exchanger, which means there is no mixing of foul air and fresh supplied air to the facility
- large exchange surface in the recuperator, with long flow of both air streams, like in a countercurrent exchanger
- countercurrent air flow through the exchanger (HRU-ERGO recuperator);
- automatic control system which automatically adjusts heat exchange efficiency to actual needs.

**Advantages:**

- high energy recovery - countercurrent heat exchanger (more than 90%)
- moisture recovery - thanks to a special exchanger structure
- exchanger - fresh and expelled air does not mix
- exchanger is protected by antibacterial coating
- high quality filters - ensure fresh and clean air
- heavy duty ventilators intended for long, continuous operation
- by-pass - allows operation in different climate conditions
- simple construction - easy installation and maintenance
- low energy consumption
- three running speeds
- small size
- easy control

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**Table 1. Sizes of particles found in the air**

<table>
<thead>
<tr>
<th>Rodzaj gazu</th>
<th>CO2</th>
<th>NH3</th>
<th>CH4</th>
<th>H2O</th>
<th>Wielkość oczka [nm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Średnica [nm]</td>
<td>0,324</td>
<td>0,308</td>
<td>0,324</td>
<td>0,288</td>
<td>0,3</td>
</tr>
</tbody>
</table>