Best products

Physics of heat transfer dictate the conditions under which the maximum heat is transferred from a primary to a secondary medium flow. The second law of thermodynamics states that heat is only transferred from a higher to a lower temperature, which sets a clear maximum for unequal flows and condensation (evaporation).

- For any heat exchanger this implies that the maximum possible heat is transferred if the outlet temperature of the primary flow equals the supply temperature of the secondary flow and vice versa that the outlet temperature of the secondary flow equals the supply temperature of the primary flow.
- To reach the maximum temperature difference the two media have to be in full counter flow in the recuperator, as otherwise part of the primary outlet flow has not exchanged heat with the supply of the secondary flow and vice versa.
- To obtain a maximum heat transfer the heat capacitance flows of both media have to be the same, as otherwise the outlet temperature of the maximum flow is lower than the supply temperature of the minimum flow, $(\dot{m} * c_p)_{primary} = (\dot{m} * c_p)_{secondary}$.
- The flow of both media has to be uniform in the recuperator as otherwise the condition of equal heat capacitance flow is locally disturbed, leading to exergy loss and not optimal use of heat exchanger material. This further implies that the pressure loss in the header has to be much lower than in the ducts as the unequal lengths of cold and warm part of a trajectory in the headers cause different flows due to the unequal viscosity and velocity of the medium.
- To realize maximum heat transfer, the ratio of the heat exchanging capacitance to the heat capacity flow has to be very high. This ratio is also called the **N**umber of **T**ransfer **U**nits (**NTU**). $(kA >> \dot{m}\ c_p, NTU >> 1)$.
- To achieve maximum heat transfer the separation wall between the two media has to be a bad conductor for heat in the direction of the flows, as otherwise the warm supply temperature is decreased and the cold supply temperature increased, degrading the maximum temperature difference and hence the heat transferred. Contrary the heat conduction of the wall material perpendicular to the flow, in the direction of the heat flow, has to be preferably good.
- Leaks between the primary and secondary media decrease the maximum of heat transferred from the primary to the secondary medium, as only part of the intended medium is delivered and not all heat is transferred.

— Pressure drop causes a hydraulic loss. The lowest ratio of pressure drop to specific heat transfer is obtained with laminar flow in ducts with a small diameter. Turbulent flow may show a larger specific heat transfer, but also a much higher pressure drop and only leads to a better ratio for large ducts.

Further, if condensation and evaporation are possible at the given supply air conditions, some extra restrictions apply to obtain maximum heat transfer.

— The mass flow of water condensing and freezing in the secondary medium has to be equal to the mass flow of water evaporating and sublimating in the primary medium, as the condensation and freezing heat cannot be used to heat the primary medium above the supply temperature of the secondary medium or vice versa.
— Local in the recuperator the mass flows of water changing phase have to be the same, due to the same reason as above. This implies that the heat flow produced at condensation and freezing goes directly through the separation wall to be directly consumed by evaporation and sublimation.
— Condensate or ice are not allowed to leave the recuperator, as then potential heat is lost.
— For the same reason mist flow is not allowed.
— Water supply for sublimation cannot be supplied via the cold side of the recuperator due to freezing before reaching its destination.