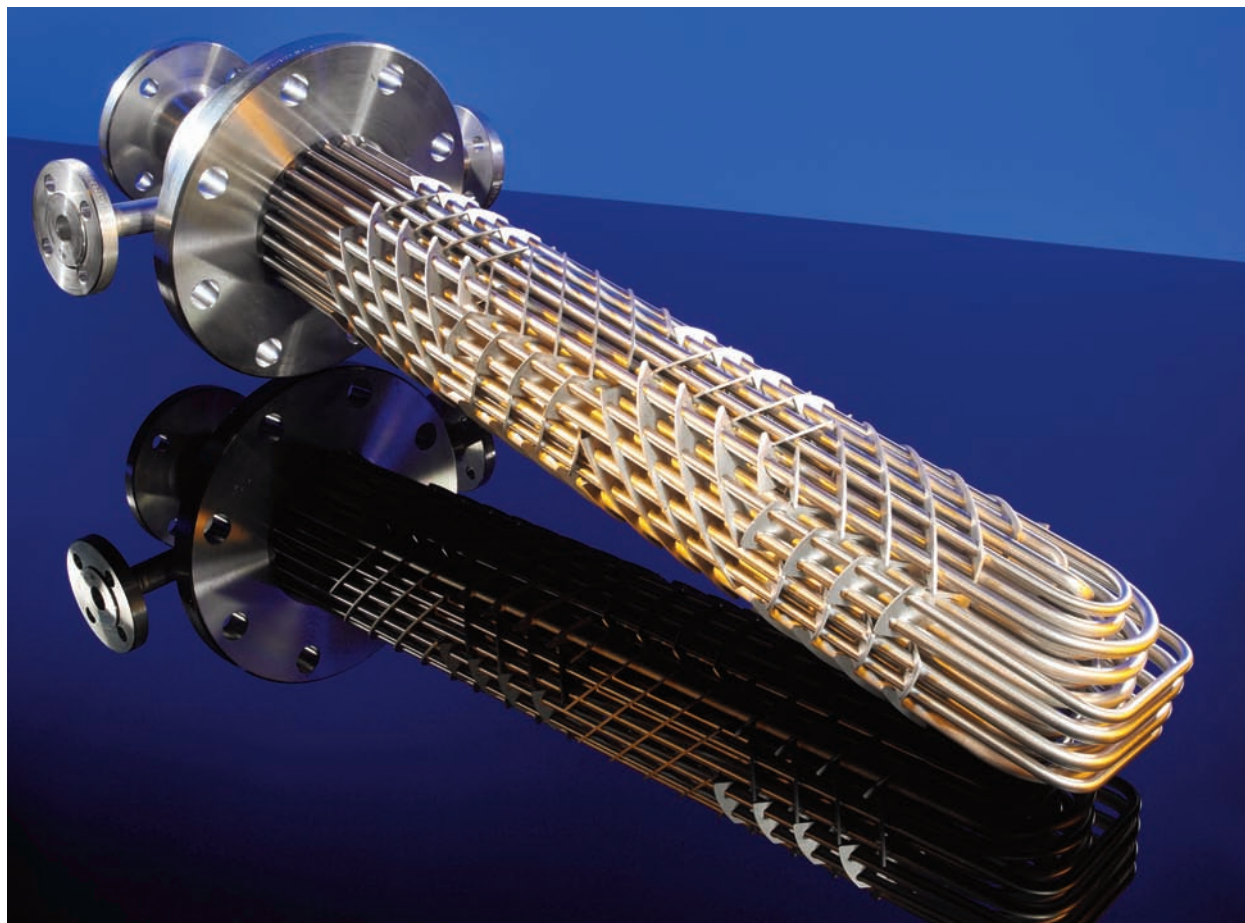


Fluitec Documentation No. 11.147 Rev. 1

Mixer-Heat Exchanger

CSE-XR® of the 3rd Generation

Fluitec's mixer-heat exchanger CSE-XR® of the 3rd generation is based on the reliable geometry of the CSE-XR®, but it is equipped with additional mixing blades. This novel design achieves a mixing performance comparable to the static mixer CSE-X/8, which is unreachable for all other types of heat exchangers. The improved mixing performance also increases the heat transfer performance. This new generation of mixer-heat exchanger can therefore be built much shorter than comparable devices, and it also can be used for unit operations like intense mixing at high heat- and mass-transfer rates at the same time. The CSE-XR® of the 3rd generation opens economic and powerful prospects for the use of mixer-heat exchangers in the reaction- and polymerisation technology.



Heat Transfer Increased by 30 to 50%

Fluitec's mixer-heat exchanger CSE-XR® of the 3rd generation is based on the reliable geometry of the CSE-XR®, but it is equipped with additional mixing blades. The increased number of mixing bars significantly improves the mixing- and heat-transfer performance. Practical tests and CFD-calculations (Computed Fluid Dynamics) both attested improvements by 30 to 50%. Of course, the resistance

factor is also increasing. Due to the reduced necessary length of the CSE-XR® mixer-heat exchanger, however, the absolute pressure drop will only be about 10 to 20% higher.

It must be pointed out, that the higher mixing performance also allows the use of larger diameters. Due to the exponential function of the diameter on the pressure drop, only some millimetre more can generate a significantly smaller pressure drop.

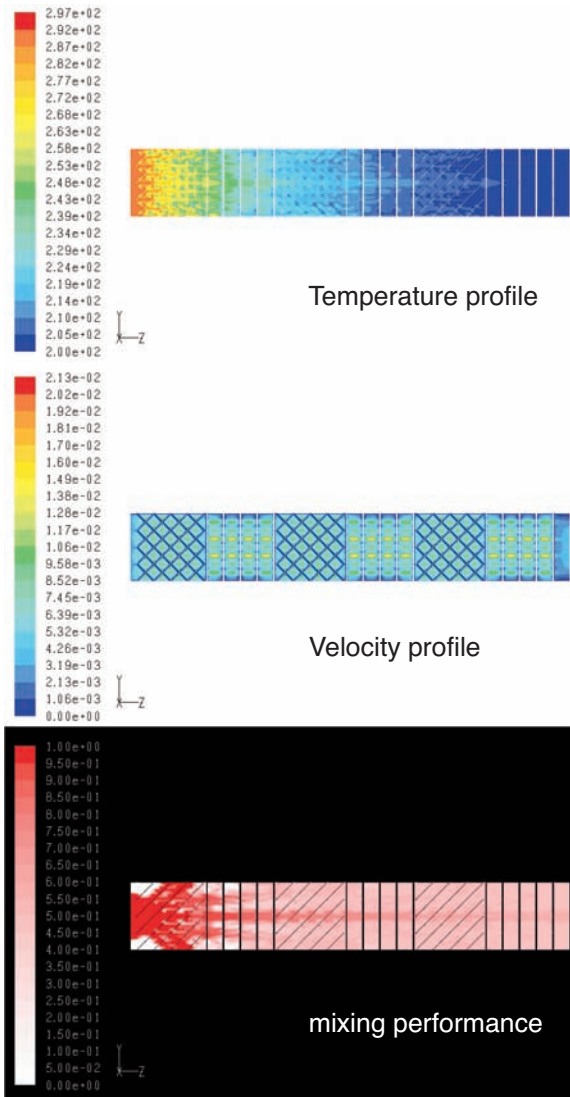


Fig. 2 CFD-Simulation of a cooling process

Pict. 2 shows the results of a CFD-calculation of the temperature profile in a CSE-XR[®] mixer-heat exchanger of a difficult cooling process. The homogeneous temperature profile over the cross section is well visible. Deviations of 1 to 2°C are normal. It is also obvious that no by-pass effects at the reactors wall appear, and that, at the same time, no breakthrough in the centre occurs.

Mixing Efficiency Comparable to the Best Static Mixers

The mixing efficiency of the CSE-XR[®] mixer-heat exchanger of the 3rd generation is outstanding. Practical and theoretical based investigations led to the conclusion that its performance is equal the most efficient type of static mixers. Fig. 3 shows the relative standard deviation, expressing the grade of the mixing quality. It indicates that the heat exchanger of the 3rd generation is able to compete with the mixing performance of the CSE-X/8 mixer, whereas the mixer-heat exchanger of the 1st generation is mixing well, but not good enough for very sophisticated mixing tasks. However, it must be kept in mind that also factors such as the shear rate, the diffusion rate, etc. can influence the mixing task.

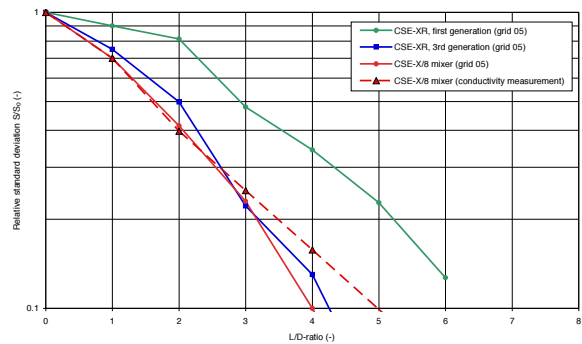


Fig. 3 Relative standard deviation of the CSE-XR[®] mixer-heat exchanger compared to the static mixer type CSE-X/8[®].

Excellent narrow residence

The excellent narrow residence time distribution in the CSE-XR[®] mixer-heat exchanger is remarkable and a very important any typical feature. *Bodenstein*-numbers of $Bo = 400$ make this device very interesting e.g. for the continuous chemical reaction technology. Due to the fact that plug-flow is almost achieved, the self-cleaning efficiency is also very high and very reliable. It's an empirical value that, depending on the properties of the liquids, the reactor will be perfectly cleaned after flushing with 2- to 4-times of the reactors volume.

Typical Design Features

The most typical design features of the CSE-XR[®] mixer-heat exchanger are the following ones:

- the complete mixing- and heat-exchanging unit is easily removable as one package
- the complete surface can controlled and reproducible be cleaned and also sterilised
- along its longitudinal axis, the cross-sectional area of the CSE-XR[®] mixer-heat exchanger is uniform, thus preventing any maldistribution. Plug-flow-like flow is always guaranteed
- due to the high specific heat-exchanging area, the CSE-XR[®] mixer-heat exchanger is dedicated for highly viscous and temperature sensitive media

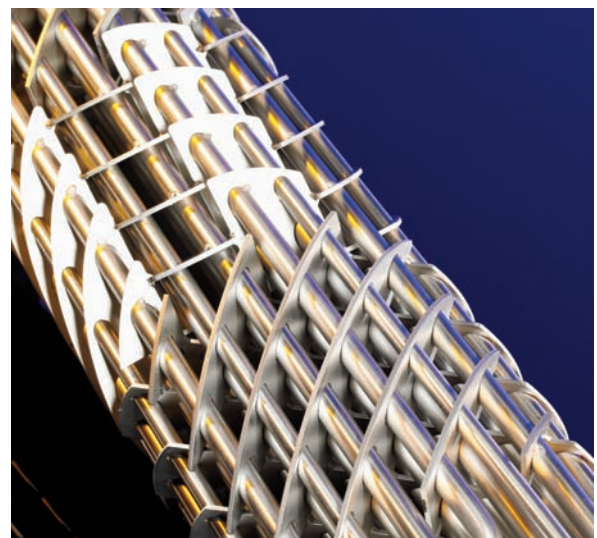


Fig. 4: CSE-XR[®] mixing element of the 3rd generation