

Fluitec Documentation No. 11.101 Rev. 2

Mixer - Heat Exchanger CSE-XR[®] Reactor

By combining static mixing elements with shell-and-tube heat exchangers, basic operations such as mixing, heat and mass transfer for chemical reactions are now possible even for highly viscous liquids. The excellent heat transfer performance and the high mixing efficiency of the CSE-XR[®] allows delicate operations also in laminar flow.

CSE-XR: the next generation

The new CSE-XR Mixer / Heat Exchanger or Reactor opens cost-saving opportunities in the field of chemical reactions and polymerization processes.

Using specially designed static mixing elements (Fig. 1), a strongly defined cross sectional mixing behavior and a high surface renewal rate are achieved, making the CSE-XR suitable for strong exo- and endothermic chemical reactions. Temperature control and equilibration is achieved exactly and completely at all flow conditions.



Fig. 1: The new CSE-XR Mixer / Heat Exchanger

A perfect combination

The very high mixing efficiency is characteristic for conventional CSE-X mixing elements in general. By increasing the tubes diameter, however, the CSE-X elements reach its limit for the use in monotube heat exchanger. In diameters greater than DN 80, the heat transfer coefficient α_i is in inverted ratio to the diameter D:

$$\text{Eq. 1: } \alpha_i = \frac{Nu \cdot \lambda}{D}$$

In order to compensate the decreased heat transfer efficiency, additional surface is necessary for

energy transfer, marking the equipment more expensive in investment and operation costs. This problem can be solved by inserting additional heat exchanger tubes into the existing device. Thereby the new, inner tubes pierce the static mixing elements and benefit in the same way from the mixing efficiency as the outer, conventional tube. The additionally created surface area and the achieved high Nusselt-number in the CSE-XR create a remarkable high heat transfer in relation to its volume. Fig. 2 shows the performance of CSE-XR in relation to traditional apparatuses and its superiority especially in large-scale plants.

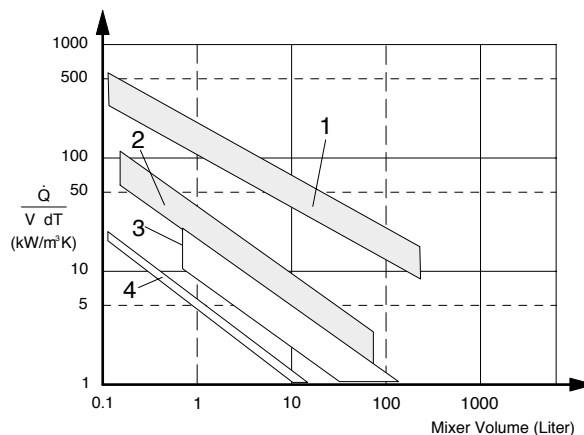


Fig. 2: Heat transfer in function of the reactor volume

- 1 Fluitec CSE-XR Mixer / Heat Exchanger
- 2 Monotube heat exchanger equipped with a static mixer
- 3 Stirred vessel
- 4 Monotube heat exchanger without static mixer

To guarantee the high mixing efficiency, the CSE-XR Mixer / Heat Exchanger is constructed in a high ratio of length to diameter. Operating conditions up to a pressure of 5000 psi (PN 400) and a temperature of 600°F (315 °C) are possible.



Fig. 3: CSE-XR Mixer / Heat Exchanger 10 inch / 5000 psi (DN250 / PN400)

Residence time distribution in the CSE-XR Reactor

Very interesting in terms of security, investment and operating costs is the high mixing efficiency of the CSE-XR Reactor, which allows the construction of smaller heat exchangers. Additionally, different investigations lead to the discovery, that the CSE-XR has a remarkable narrow residence time distribution. This is an important advantage for sensitive reactions such as polymerizations. Fig. 4 represents residence time measurements in an empty tube and in a CSE-XR Reactor, indicating, the almost perfect plug flow achieved. This effect is also of advantage in self-cleaning processes. A delta Diracpulse of dye visualized the excellent self-cleaning efficiency of the CSE-XR Reactor, whereas in the empty tube a colored zone remained close to the wall over long terms. Experiments were carried out using glucose syrup with a viscosity of 10 Pa s to 100 Pa s.

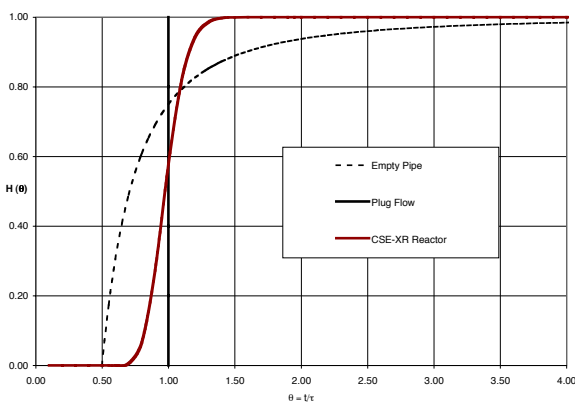


Fig. 4: Residence time distribution in the CSE-XR Reactor

Features

The constructive characteristic of the new CSE-XR

Mixer / Heat Exchanger can be described as followed:

- the Mixer / Heat Exchanger part is removable as a singular unit.
- cleaning and sanitation of the complete surface is reproducible and controllable.
- the constant cross-sectional area is geometricaly defined, guaranteeing low maldistribution and a narrow residence time distribution.
- the high performance of the CSE-XR makes this device especially suitable for fluids of high viscosity or temperature sensitivity.

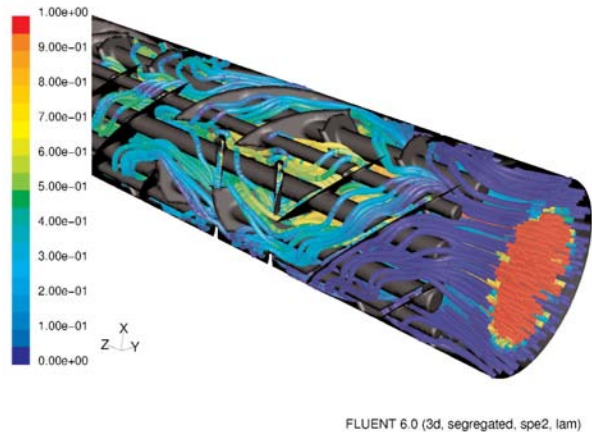


Fig. 5: CFD Calculation (laminar flow)

Fields of application

The CSE-XR is setting a new standard in mixing and reaction processes. It will fulfill the highest demands of our clients:

- for exothermic reactions of highly viscous fluids such as polymerizations, where not only heat transfer but also high mixing efficiency and a narrow residence time distribution is of highest importance.
- to equilibrate temperature in fluids of low viscosity that show a fast and strong exo- or endothermic reaction.
- as a plug flow or loop reactor in often strongly confidential key-processes in chemistry.
- as a continuous reactor for reactions that require a narrow residence time distribution.

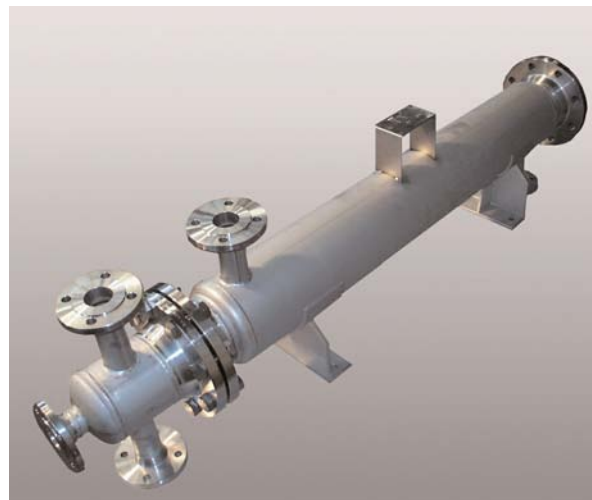


Fig. 6: CSE-XR Heat Exchanger / Design B2