Principles of Operation

Liquid / Liquid laminar flow of miscible fluids

Flow Division

The main mechanism in laminar flow in a static mixer (Reynold's number < 2000) is *flow division* .
Statiflo element styles STT, STS and STL are either helical or pseudo-helical and are arranged in a series of alternating left and right hand 180° twists. The leading edge of an element, which is on a diameter, is at 90° to the trailing edge of the upstream element.

In flow division, the leading edge of the first element splits the fluids entering the mixer into 2 streams, which are then rotated through 180°. The second element splits the flow again, this time into 4 streams, followed by a further rotation, in the opposite direction, through 180°. The third element repeats the process by splitting into 8 streams, and so on. As the number of streams or layers increases, the layer thickness decreases. Typically, 12 to 24 elements are required to provide a complete mix.

Mixture quality is a function only of mixer diameter and number of elements and, in laminar flow, is independent of flowrate and viscosity.

Liquid / Liquid turbulent flow of miscible fluids

At higher Reynold's numbers, much greater than 2000, a second mixing mechanism, acting simultaneously with flow division, becomes important to the overall mixing process:

Radial Mixing

In general terms, the fluid viscosity in turbulent flow is lower than in laminar flow. The element shape is now able to impart a rotational spin to the fluids, which changes direction with each succeeding element. Fluids are constantly moved from the pipe centre to the pipe wall and back again, with the interface between elements a particularly active zone. This mechanism is called radial mixing, which dominates the flow division mechanism in turbulent flow. It very rapidly eliminates radial differences in, for example, composition, colour, pH, temperature and velocity.

The number of mixing elements required to achieve a fully homogeneous mix in turbulent flow applications is much less than in laminar flow and is typically 1.5 to 4 elements.

Liquid / Liquid turbulent flow of immiscible fluids

The radial mixing mechanism is important in reducing radial differences in velocity and therefore shear rate. The even shear history results in a predictable average droplet size where approximately 80% of the dispersed phase is within ±20% of the average droplet size. An open pipe, without controlled mixing, provides a huge range of droplet sizes with far less surface area of contact between phases.

The average droplet size is velocity dependent, with the terminal droplet size approached after 4 elements.

Gas / Gas turbulent flow

In engineering terms, gases are low viscosity fluids. The Statiflo Static Mixer behaves in the same manner as in the Liquid / Liquid turbulent flow classification.

Solid / Solid particulate flow

Both flow division and radial mixing mechanisms are fundamental to the mixing of free flowing particulates. However, this classification is complex due to the large number of parameters affecting flow and mixture quality and is an area requiring further study.