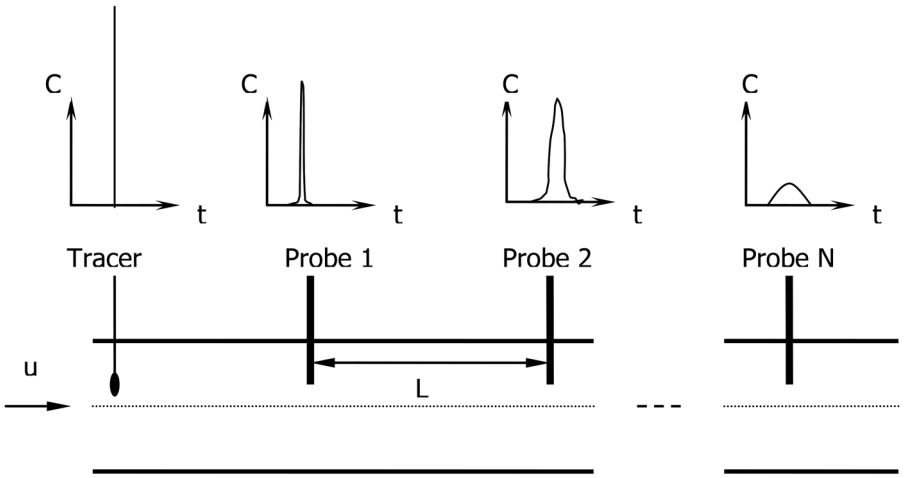

Figure 3.2 Concentration profile of a tracer travelling through a tube.[6]

of the degree of plug flow achievable. For plug flow, the area under the C curve equals to 1, and the width of the curve to 0. This is not possible in the real world, which is why ideal plug flow cannot be achieved.

Using the measured profiles of tracer concentration, the degree of deviation from the true plug flow (*i.e.* the spread) or the axial dispersion coefficient (D) can be quantified. The unit of D is taken as the area spread by tracer per time ($m^2\ s^{-1}$). The lower the value of D, the closer it is to plug flow. Figure 3.3 shows the concentration as a function of a dimensionless time for various axial dispersions. When the dimensionless group of D/uL equals zero, it is a true plug flow; when D/uL approaches infinity, the system behaves as a single continuous stirred tank, where L is the distance (m) between the tracer injection port and the location of the probe in question, which can also be the reactor length.

Another popular method to measure plug flow is to use the Tanks-in-Series model, which views the fluid as flowing through a series of equal-size ideal continuous stirred tank reactors (CSTRs). The number of tanks (N) can be evaluated experimentally from the RTD, Figure 3.4 shows the correlation between the number of tanks and the state of plug flow being achieved. When $N \rightarrow \infty$, it is a true plug flow. When $N = 1$, it is a CSTR system. This confirms that the state of plug flow can never be obtained in a single tank.

3.2.3 How Could Near Plug Flow Be Achieved in the Real World?

Near plug flow can be achieved by using either a number of CSTRs in series or turbulent flow in a tubular reactor. In the former, ideal plug flow would require an infinite number of CSTRs, but this is not feasible. In practice, three to eight CSTRs in series are the typical numbers in most companies I visited. The more reactors are used, the more inventory, capital and energy are needed, not to mention the fact that it is still far from a true plug flow.