VISIMIX CHEM
Continuous Flow Process: Influence of feed position in multi stage impeller

Previous study overview (Demo Project 3.1):

The previous report, titled **Continuous Flow Process: Multistage Impellers in the shaft**, investigated impact of the 3-stage paddle with Feed 1 located near the top of the reactor, delivering feed downward along the axis, and **Feed 2 positioned at the bottom side of the reactor wall** equipped with four baffles to promote uniform distribution. Reactant A achieves a conversion of **0.904** in the actual reactor, slightly below the ideal reactor's **0.914**, while Reactant B achieves **0.93**, compared to the ideal reactor's **0.94**. This difference is likely due to non-ideal flow dynamics, localized mixing zones, or dead zones hindering its efficiency.

The product concentration in the actual reactor is **0.04 mol/L** with the by-product concentration at **0.42 mol/L,** indicating increased by-product formation. This is likely due to suboptimal flow patterns or insufficient local mixing, leading to side reactions. The reactor design, particularly the feed inlet positions and baffle configuration, appears to influence reaction dynamics, contributing to inefficiencies in product formation and by-product minimization.

Current study overview:

The current study focuses on investigating the continuous flow process with a modified feed inlet location for Reactant B. In this configuration, Inlet 2 is positioned on the **top side** of the reactor wall at a radius of 500 mm and a height of 1500 mm from the base. This change in inlet positioning is expected to influence the distribution and mixing of Reactant B within the reactor. By analyzing this modification, we aim to understand how the feed location impacts mixing efficiency and overall reactor performance.

Objective:

This report aims to analyze the impact of varying the Feed 2 (Reactant B) inlet position on the mixing, distribution and overall performance of a continuous process.

The Solution:

To update the location of **Inlet 2** (Reactant B), navigate to the Edit Input>Mechanical Design>Inlet and Outlet locations section.

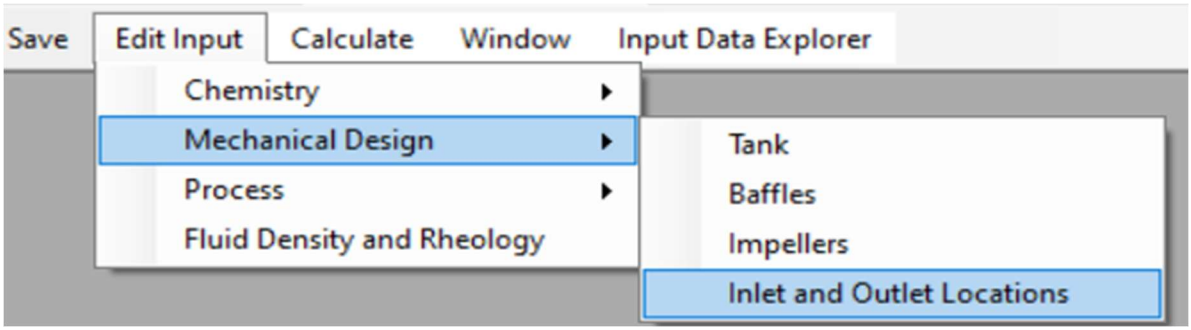

Figure 1. Edit Input – Mechanical Design menu for Inlet Location

The location of inlet 2 for Reactant B needs to be updated to position it near the top side of the reactor wall, with a radius of 500 mm and a height of 1500 mm from the base. This change in inlet positioning is expected to influence the distribution and mixing of Reactant B within the reactor, potentially improving the efficiency of the reaction by reducing localized flow issues and enhancing overall reactant utilization.

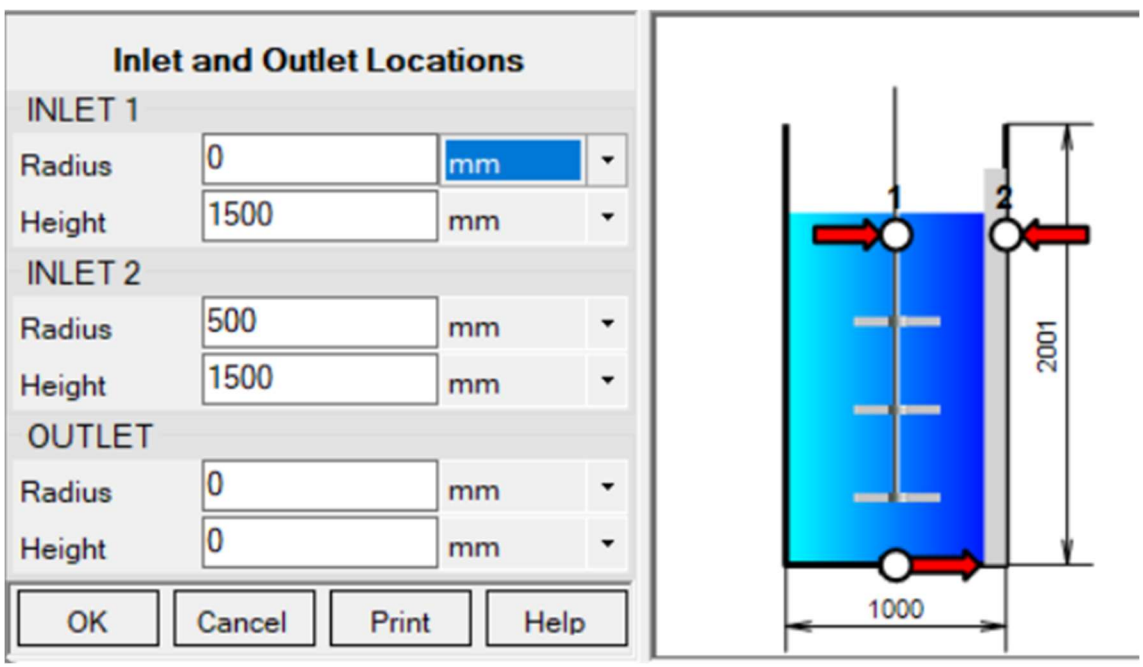

Figure 2. Update the Inlet 2 location

RESULTS:

Next, navigate to the **Calculate** menu, then select Continuous Process > Final Parameters > Average Composition, and run the simulation. Once the simulation is complete, return to the Calculate menu and select Continuous Process > Final Parameters > Average Composition again. This will provide the composition values, taking into account both the actual reactor conditions and perfect macromixing.

Continuous Flow Process—Average Concentrations, mol/L

At the end of the transient process of requested duration

	Reactant Designation	Actual Reactor–Tank	Actual Reactor–Product Stream	Reactor with Perfect Macromixing
▸	A	0.0718	0.02656	0.08615
	B	0.02458	0.005706	0.02895
	P	0.02949	0.01509	0.02826
	BP	0.4454	0.4761	0.4334
*				

Figure 3. Average concentration in the reactor mol/L

If you navigate to the Non-Uniformities section under the Final Parameters> Non-Uniformities calculation, the following window will appear:

Continuous Flow Process—Concentration Non-Uniformities in Actual Reactor, mol/L

At the end of the transient process of requested duration

	Reactant Designation	Local Concentration Standard Deviation	Difference between the Maximum and Minimum Local Concentrations	Average Concentrations
▸	A	0.04364	0.1555	0.0718
	B	0.02225	0.07981	0.02458
	P	0.01222	0.03283	0.02949
	BP	0.02968	0.09389	0.4454
*				

Figure 4. Concentration Non-Uniformities in Actual Reactor, mol/L

Next, navigate to Final Parameters> **Conversion** calculation, the following window will appear:

Continuous Flow Process—Reactant Conversion

At the end of the transient process of requested duration

	Reactant Designation	Actual Reactor–Product Stream	Reactor with Perfect Macromixing
▸	A	0.9734	0.9138
	B	0.9886	0.9421
	P		
	BP		
•			

Figure 5. Reactant conversion

We can navigate to the Calculate menu>Continuous flow process>Charts to view the concentration versus time for each reactant and product as well as the conversion versus time for each reactant.

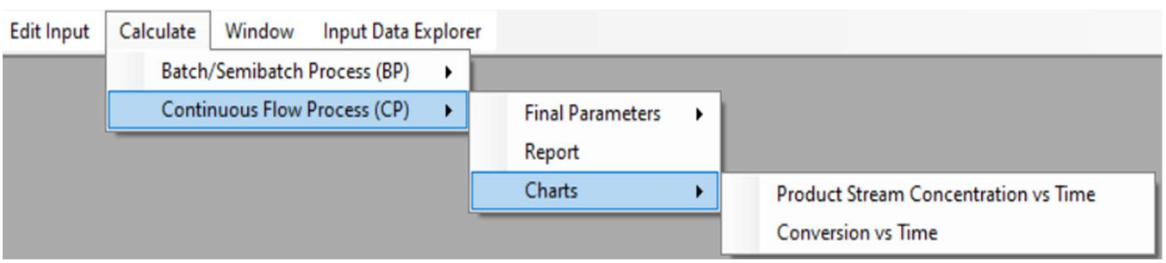

Figure 6. Select Calculate Menu- Charts

Product Stream Concentration Vs time graph in Product Stream

The concentration versus time graphs for each reactant, product and by-product are presented below, considering both the actual reactor and the reactor with perfect macromixing.

Reactant A

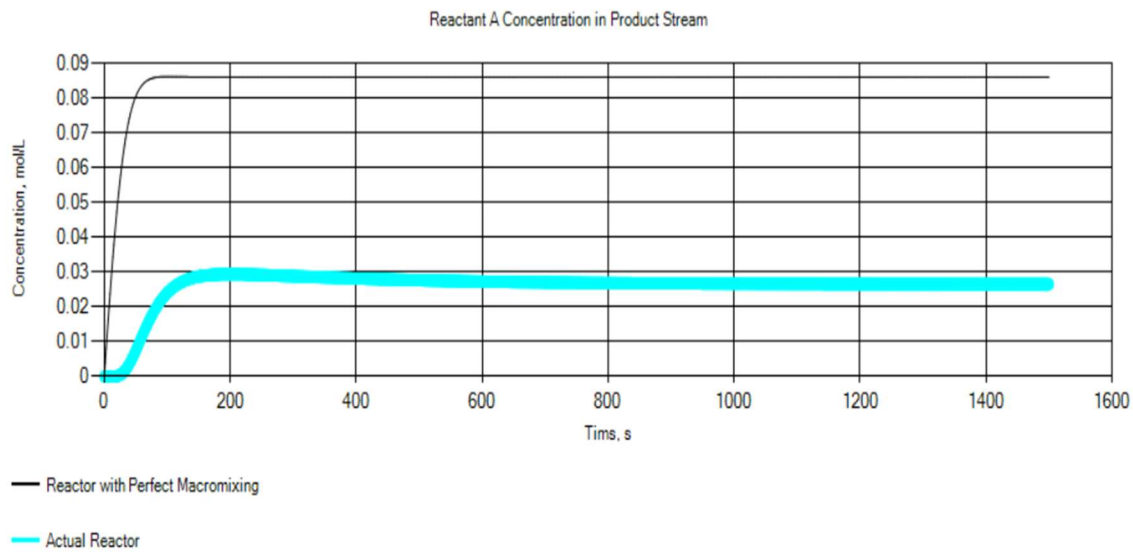

Figure 7. Concentration Vs time graph – Reactant A

The graph illustrates the concentration of Reactant A in the product stream as a function of time for both an actual reactor and a perfect macromixing reactor. In the actual reactor, the concentration gradually increases, stabilizing at approximately **0.026 mol/L** after **1400 seconds**, whereas the perfect macromixing reactor reaches the steady-state concentration much faster, within about **100 seconds** at **0.086 mol/L.**

Reactant B

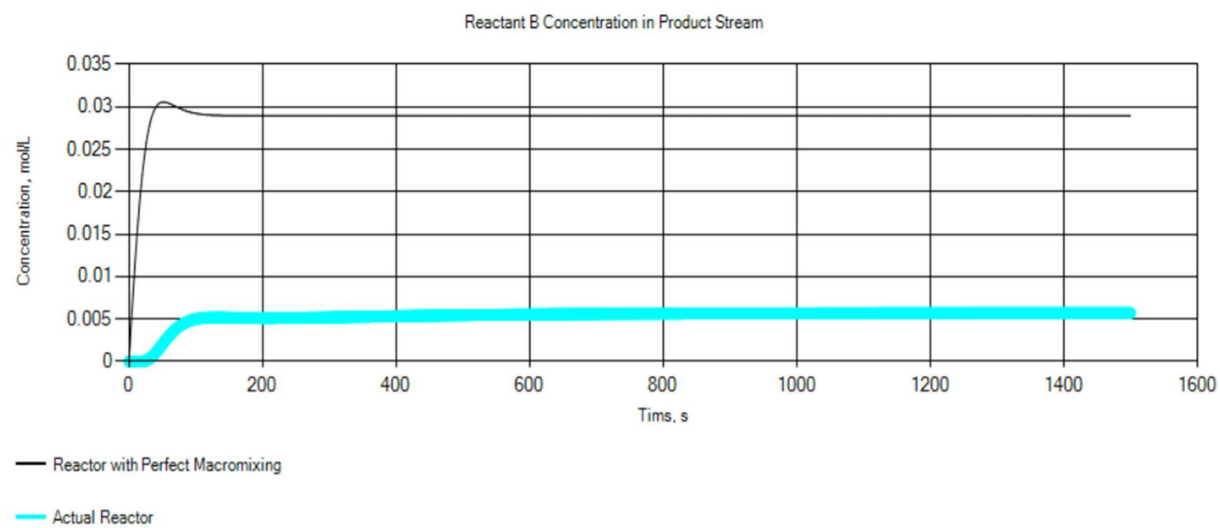

Figure 8. Concentration Vs time graph – Reactant B

In the actual reactor, the concentration of Reactant B reaches at steady-state near **0.006 mol/L**

after approximately **100 seconds**. In contrast, the perfect macromixing reactor reaching steady-state at concentration of **0.028 mol/L** within about **200 seconds**.

Product P

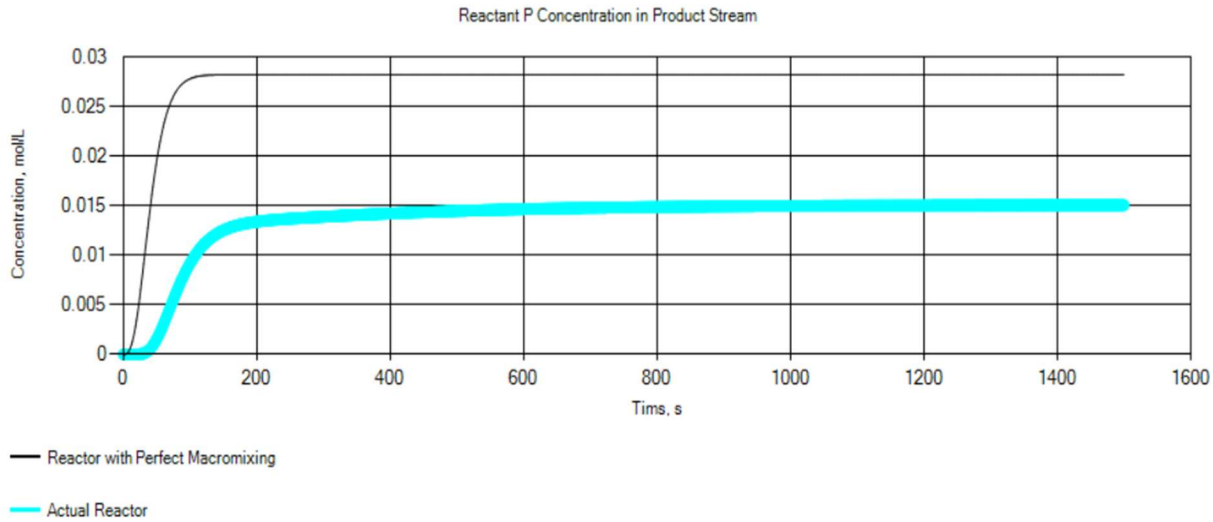

Figure 9. Concentration Vs time graph – Product P

In the actual reactor, the concentration of Reactant P reaches at steady-state near **0.015 mol/L** after approximately **600 seconds**. In contrast, the perfect macromixing reactor reaching steady-state at concentration of **0.028 mol/L** much earlier, within about **100 seconds**.

By-product BP

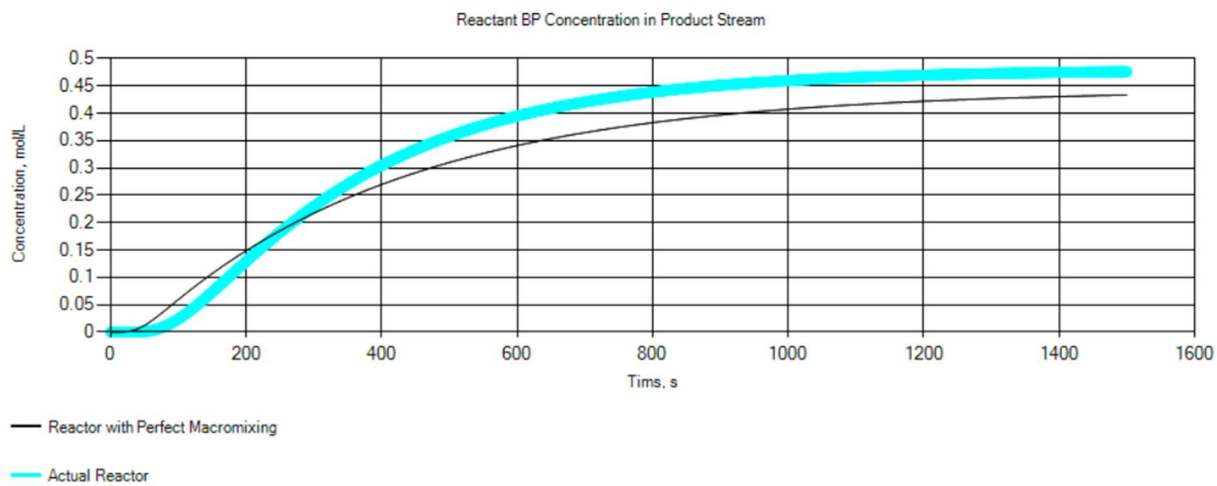

Figure 10. Concentration Vs time graph – By-Product

In the actual reactor, the concentration of by-product increases steadily, reaching a final steady-state value of approximately **0.476 mol/L** after about **1400 seconds**. The perfect macromixing reactor also reaches the steady-state concentration **0.43 mol/L**, stabilizing around **1500 seconds**.

Conversion Vs time graphs

The conversion versus time graphs for each reactant are presented below, considering both the actual reactor and the reactor with perfect macromixing.

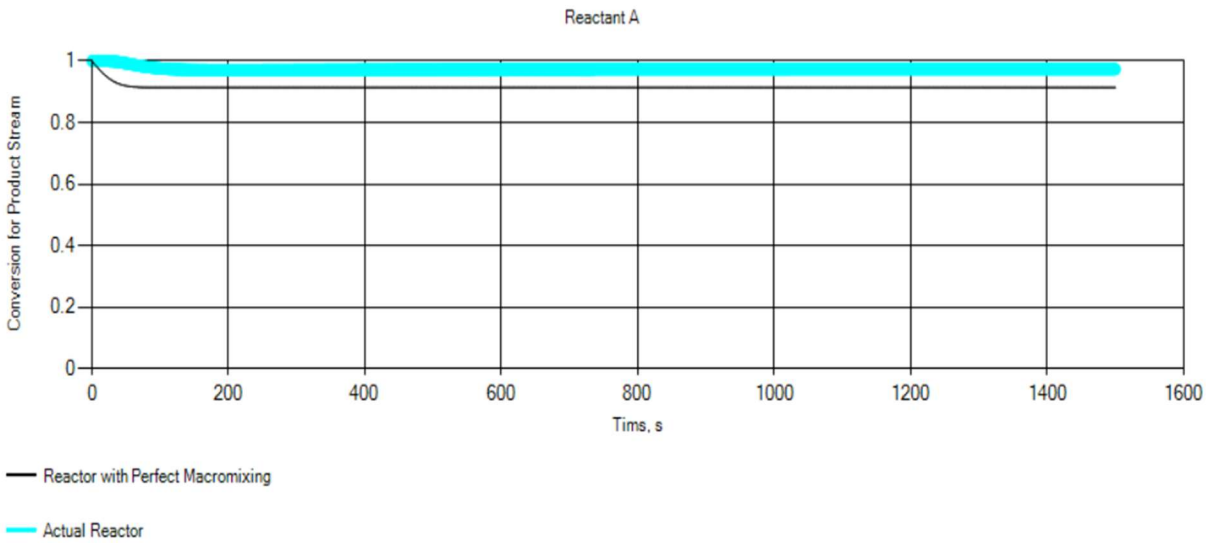

Figure 11. Conversion Vs time graph – Reactant A

The graph shows that initially, the conversion fluctuates slightly during the transient phase as the system stabilizes. Ultimately, Reactant A achieves a conversion of **0.973** in the actual reactor which is slightly higher than the ideal reactor's conversion **0.914**, demonstrating that the actual reactor effectively converts Reactant A, indicating efficient local micro-mixing and good mixing performance within the reactor system.

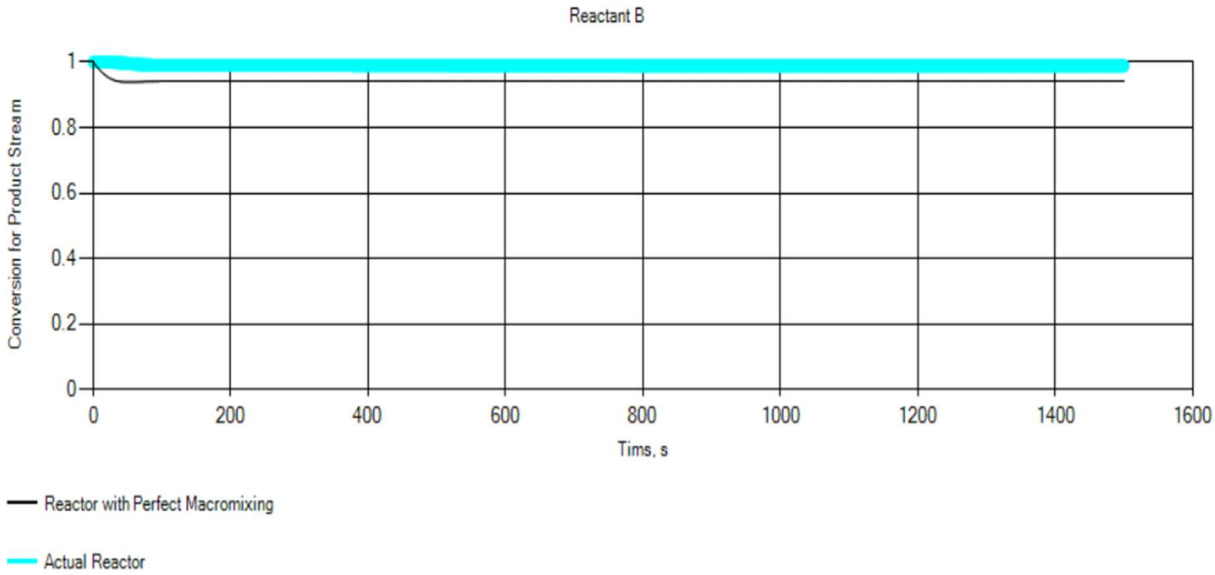

Figure 12. Conversion Vs time graph – Reactant B

This graph shows that Reactant B achieves a conversion of **0.988** in the actual reactor, which is higher than the **0.942** observed in the ideal reactor demonstrating that the actual reactor effectively converts Reactant B.

Results Overview:

The current study evaluates the impact of relocating the feed 2 inlet to **the top side** of the reactor wall, positioned at a radius of 500 mm and a height of 1500 mm from the base, compared to the previous configuration with the inlet near the **bottom side of the reactor wall**. Reactant A achieved a conversion of **0.973** in the actual reactor, surpassing both the ideal reactor's **0.914** and the previous study's **0.90**, demonstrating improved performance. Similarly, Reactant B exhibited enhanced conversion, achieving **0.988** in the actual reactor compared to the ideal reactor's **0.94,** and outperforming the prior setup, where the actual conversion was only **0.93**.

Furthermore, the product concentration in the actual reactor is **0.015 mol/L** with the by-product concentration at **0.476 mol/L,** indicating increased by-product formation compared to previous product concentration of **0.04 mol/L** and byproduct concentration of **0.42 mol/L**. This suggests that, despite improved conversion rates, the altered feed position may favor side reactions, leading to higher by-product formation and reduced product yield.