NEWSLETTER

Gas- Liquid Mixing in Fermentation using VisiMix

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School of Scale-Up (SOS): A New Concept Offering

- Increasing productivity in research, scale-up and manufacturing are key goals for all chemical industries as the time to market shortens to meet fast-paced technology needs.
- With the resources at your disposal, how can you achieve the next level of productivity.
- Technologists need to think outside-of-the-box with novel methods and approaches to solve the practical challenges of Scale-up and Scale-down quickly.

Utilizing your lab and facility resources we will design simple test experiments to show your team how mixing influences your process challenges and how to overcome your existing limitations.

With VisiMix software we will show you how to quickly analyze and understand your process to achieve successful scale-up.

Our training is intuitive, insightful and practical. The hands-on demonstrations are accessible to technicians, chemists and engineers at all levels. We are two companies working together with a unique offering.

Watch the full video here

Introduction

Fermentation is one of the most widely used processes in biotechnology and pharmaceuticals, ranging from antibiotics and enzymes to biofuels and food ingredients. A key factor for successful fermentation is the efficient supply of oxygen, since microorganisms rely on it for growth and product formation.

This oxygen transfer is governed by gas–liquid mixing, which is strongly influenced by the type of impeller used in the bioreactor. Choosing the wrong impeller can lead to insufficient oxygen transfer, resulting in reduced cell growth and lower yields; excessive shear stress, which may damage sensitive organisms such as fungal cells; and high energy consumption, driving up operational costs without proportional benefits.

Traditionally, engineers have relied on pilot plant trials to test different impeller designs, but this approach is often time-consuming, costly, and may not fully capture scale-up risks. VisiMix overcomes these challenges by providing a virtual environment to simulate hydrodynamics, turbulence, and gas dispersion. This enables engineers to compare impeller options, predict oxygen transfer, and evaluate shear effects, making it possible to make informed choices for fermentation processes before running a single experiment.

The Challenge

In fermentation, selecting the right impeller is not straightforward because multiple competing factors must be balanced.

Engineers must ensure:

- **Energy efficiency** – mixing power should be minimized without sacrificing performance.
- **Oxygen transfer** – ensuring microbes receive enough dissolved oxygen.
- **Shear protection** – preventing cell damage in sensitive cultures.

The specific challenge was to compare two mixing devices—a **2-stage Pitch Paddle and a 2-stage Rushton Turbine**—under identical air injection conditions, with the goal of identifying which impeller provides the best balance of oxygen transfer, shear control, and energy efficiency for fermentation.

The Solution

To address this challenge, VisiMix Turbulent was used to simulate the hydrodynamics, turbulence, and gas–liquid mass transfer in both reactor setups. By virtually modeling the systems, engineers could directly compare key performance parameters without the need for multiple pilot trials.

VisiMix Simulation

To evaluate gas–liquid mixing in fermentation,reactor details, baffle , impeller configuration, and reaction properties , gas flow rate, gas concentration , oxygen solubility, diffusivity were input into VisiMix Turbulent.

Case-I: 2-stage Pitch Paddle

Case-II: 2-stage Rushton Turbine

The simulations provided a direct comparison of mixing power, shear stress, and oxygen transfer under identical operating conditions.

The reactor and baffle details are same in both the cases.

TANK WITH ELLIPTICAL BOTTOM

Inside diameter	1800	mm
Total tank height	2200	mm
Total volume	5217	l
Level of media	1722	mm
Volume of media	4000	l

FLAT BAFFLE-2

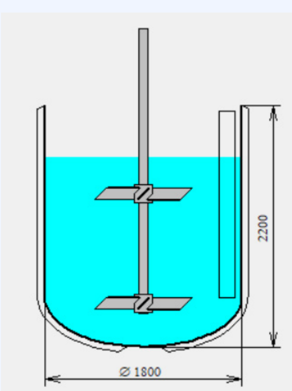
Number	4	
Width	160	mm
Length	1700	mm
Dist. from bottom	450	mm
Dist. from wall	50	mm
Angle to radius (fi)	0	deg

PITCHED PADDLE. MULTISTAGE

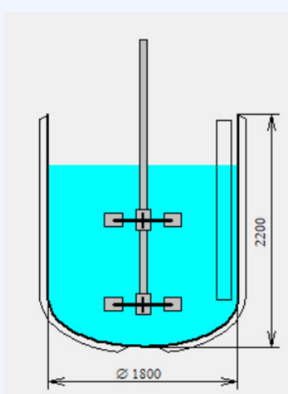
Tip diameter (D)	900	mm
Impellers number	2	
Dist. between stages	1000	mm
Number of blades	4	
Pitch angle	45	deg
Width of blade	140	mm
Dist. from bottom	400	mm
Rotational speed	85	Rpm
Motor power	7.5	KW

DISK TURBINE. MULTISTAGE

Tip diameter (D)	750	mm
Impellers number	2	
Dist. between stages	800	mm
Diameter of disk	600	mm
Number of blades	6	
Pitch angle	90	deg
Width of blade	150	mm
Length of blade (L)	175	mm
Dist. from bottom	400	mm
Rotational speed	85	Rpm
Motor power	7.5	KW



2-stage Pitch Paddle



2-stage Rushton turbine

Simulation Results:

VisiMix simulations were carried out for both impellers under identical conditions.

The following table presents the comparative simulation data for both impellers under identical operating condition.

Parameter	Units	2-stage Pitch Paddle	2-stage Rushton Turbine
Mixing power	W	3950	5240
Turbulent shear stress near the impeller blade	N/sq.m	18.1	31.8
Gas mass transfer rate	Kg/hr	10.1	10.2

The simulation results highlight important differences between the two impeller types, which are summarized in the key observations below.

Key Observations

- **Mixing Power:** The Rushton turbine required higher power input (5240 W) compared to the pitch paddle (3950 W).This means the Rushton is more energy-intensive, while the paddle provides a cost-efficient option with lower power consumption.
- **Shear Rate:** The Rushton turbine generated much higher turbulent shear stress near the blades (31.80 N/sq.m) compared to the pitch paddle (18.1 N/sq.m).High shear zones can damage shear-sensitive cells (e.g., fungal, or yeast cultures), making the Rushton less suitable for delicate fermentation processes.
- **Oxygen Transfer:** Despite the differences in power and shear, both impellers delivered almost identical oxygen transfer rates (10.2 vs. 10.1 kg/hr). This shows that the extra energy and shear generated by the Rushton did not translate into a meaningful improvement in oxygen supply.

Conclusion

- The 2-stage Pitch Paddle demonstrated better energy efficiency and lower shear stress while achieving nearly identical oxygen transfer rates compared to the 2-stage Rushton Turbine.
- For fermentation processes, especially those involving shear-sensitive microorganisms, the Pitch Paddle provides a more balanced solution. The Rushton turbine may be preferred only when maximum turbulence is required, but at the cost of higher energy consumption and shear.