

### Introduction

- Dissolution is a critical operation in many pharmaceutical, chemical, food, and specialty chemical manufacturing processes. The rate at which solid particles dissolve directly influences batch cycle time, product quality, process consistency, and overall manufacturing efficiency.
- Although increasing agitator speed is often considered the simplest solution for improving dissolution, the process is governed by several interacting factors, including particle suspension, liquid-solid mass transfer, impeller geometry, and flow circulation within the vessel. Poor mixing can lead to particle settling, prolonged dissolution times, and increased energy consumption.
- In this month's case study, we demonstrate how VisiMix was used to evaluate a liquid-solid dissolution process, identify the causes of poor dissolution performance, and optimize the impeller design to achieve complete particle suspension and significantly reduce dissolution time without increasing the operating speed.

### The Challenge

Efficient solid dissolution is essential for achieving consistent product quality and minimizing batch cycle time. However, many manufacturing processes experience slower-than-expected dissolution even when the agitator operates at the desired speed. This often indicates that the limitation is not the agitator speed itself, but the overall mixing hydrodynamics, particle suspension, and liquid-solid mass transfer within the vessel.

The process team encountered the following challenges:

- **Extended dissolution time**, resulting in longer batch cycles and reduced plant productivity.
- **Settling of larger particles** at the vessel bottom, leading to incomplete suspension and non-uniform dissolution.
- **Reduced liquid-solid mass transfer efficiency**, resulting in slower dissolution rate and extended processing time.
- **Higher operating costs**, since increasing the agitator speed alone increases energy consumption without necessarily improving dissolution performance.

### Objective

The objective of this study was to evaluate the effectiveness of the existing mixing system in achieving complete particle suspension and efficient solid dissolution. The study assessed the influence of impeller geometry on liquid-solid mass transfer and dissolution performance, while determining whether optimizing the impeller geometry could improve the mixing process, recognizing that increasing the agitator speed alone may not overcome the existing mixing limitations.

#### Specifically, the study focused on:

- Evaluating the suspension performance of the existing mixing system.
- Predicting the dissolution time of both average-sized and larger solid particles.
- Assessing the relationship between particle suspension, liquid-solid mass transfer, and dissolution performance.
- Investigating the influence of impeller geometry on dissolution performance.

## VisiMix Simulation Approach

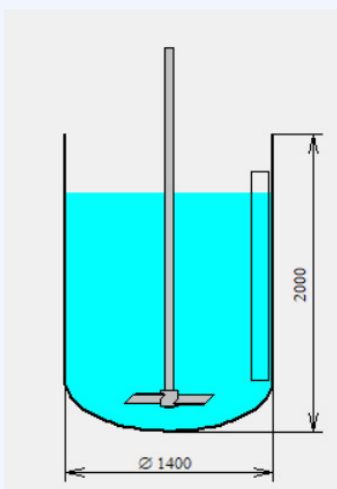
The dissolution process was simulated using the **Liquid-Solid Mass Transfer** module in **VisiMix Turbulent**. The simulation was performed using the existing reactor geometry, impeller configuration, operating conditions, and material properties to evaluate the mixing performance and dissolution behavior.

PITCHED PADDLE		PROPERTIES OF SOLID AND LIQUID PHASES.	
Tip diameter (D)	600 mm	Density of liquid phase	1000 kg/cub.m
Number of blades	2	Dyn. viscosity of cont.phase	1 cP
Pitch angle	45 deg	Concentration of solid phase	90 kg/cub.m
Width of blade	80 mm	Density of solid phase	2100 kg/cub.m
Dist. from bottom	220 mm	Average particle size	350 micron
Rotational speed	120 Rpm	Size of largest particles *	900 micron
Motor power	2000 W	Position of outlet-height	0 mm
Pumping direction	down		

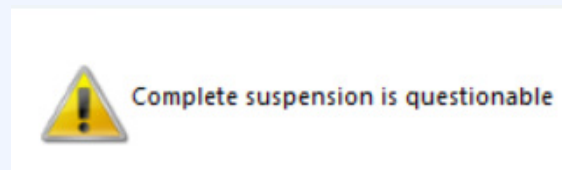
DISSOLUTION OF SOLID PARTICLES			
Initial concentration of dissolved solids	0 kg/cub.m	Solvent	water
Molecular diffusivity If unknown, enter 0 *	0 sq.m/s	Molecular weight of solvent	18
Solubility of solid	107 kg/cub.m	Molecular weight of dissolved solids	58.5
Duration of the batch	30 min	Temperature	20 °C

\* In this case molecular diffusivity will be evaluated by VisiMix. Enter YOUR data in the right part of the table



The simulation evaluated the hydrodynamic performance of the mixing system and predicted the dissolution behavior under the specified operating conditions. Key process parameters, including complete particle suspension, dissolution time, liquid-solid mass transfer, concentration of dissolved solids, and particle size reduction during dissolution, were analyzed to identify the factors limiting dissolution performance.

The initial simulation indicated that the existing impeller configuration was unable to achieve complete particle suspension, resulting in particle settling, reduced liquid-solid mass transfer, and slower dissolution.



To improve the process, the impeller design was optimized by increasing the impeller tip diameter from **600 mm to 680 mm** and increasing the number of blades from **2 to 4**, while maintaining the same operating speed. The optimized configuration was then re-evaluated to quantify its impact on particle suspension, liquid-solid mass transfer, and dissolution efficiency.

## Simulation Results

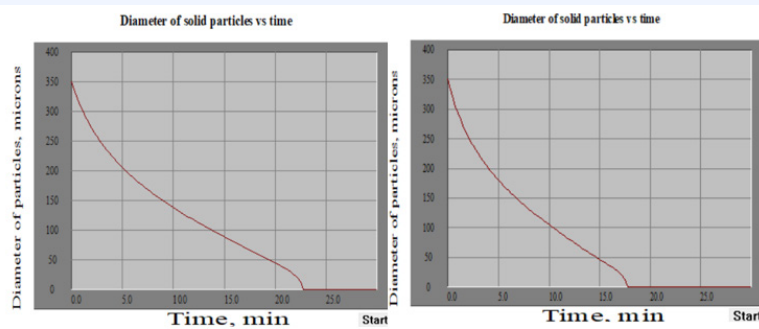
After optimizing the impeller geometry, the dissolution performance improved significantly. The optimized configuration achieved complete particle suspension, eliminated particle settling, and improved the conditions for liquid-solid mass transfer, resulting in faster dissolution under the same operating conditions.

The comparison below summarizes the key improvements predicted by the VisiMix simulation.

## Performance Comparison: Initial vs. Optimized Configuration

Parameter	Initial Configuration	Optimized Configuration
Impeller Tip diameter (mm)	600	680
No. of blades	2	4
Complete Particle suspension	Not achieved	Achieved
Estimated dissolution time (s)	1350	1050
Largest particle dissolution time (s)	9290	7030

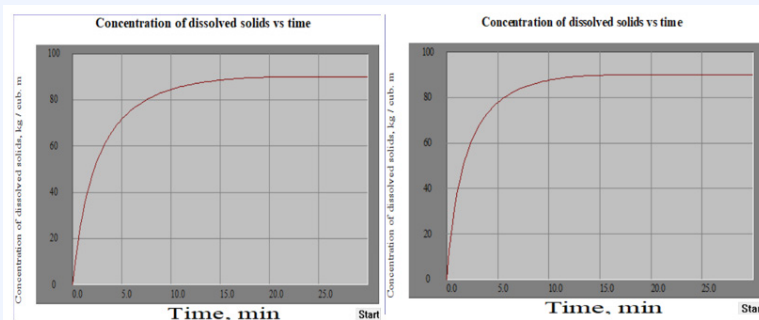
### Particle Diameter During Dissolution



Initial

Optimized

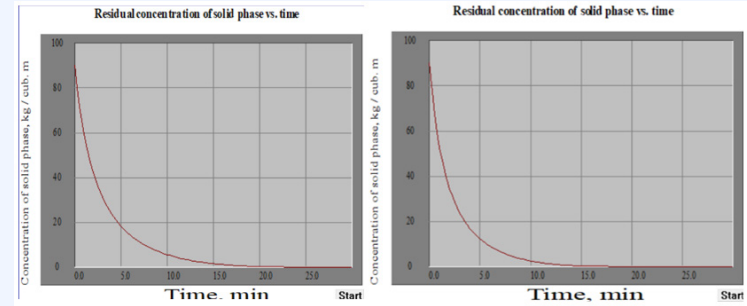
### Dissolved Solids Concentration



Initial

Optimized

### Residual Solid Concentration



Initial

Optimized

The accompanying graphs illustrate the changes in particle size, dissolved solids concentration, and residual solid concentration throughout the dissolution process, demonstrating the improved performance of the optimized configuration. The optimized configuration achieved complete particle suspension, eliminated particle settling, and enhanced liquid-solid mass transfer, resulting in approximately a **22% reduction** in the estimated dissolution time and a **24% reduction** in the dissolution time of the largest particles, while maintaining the same operating conditions.

### Key Findings

- **Complete particle suspension** plays a critical role in achieving efficient and uniform solid dissolution.
- Poor particle suspension limits liquid-solid mass transfer, resulting in longer dissolution times and reduced process efficiency.
- **Optimizing the impeller geometry** significantly improved circulation, eliminated particle settling, and enhanced dissolution performance.
- The optimized configuration reduced the estimated dissolution time for the average particle size by approximately 22% and the dissolution time of the largest particles by approximately 24%.
- Appropriate impeller selection can significantly improve dissolution performance without major equipment modifications.

- The study demonstrates that improving the mixing system through impeller optimization can be more effective than simply increasing the agitator speed.

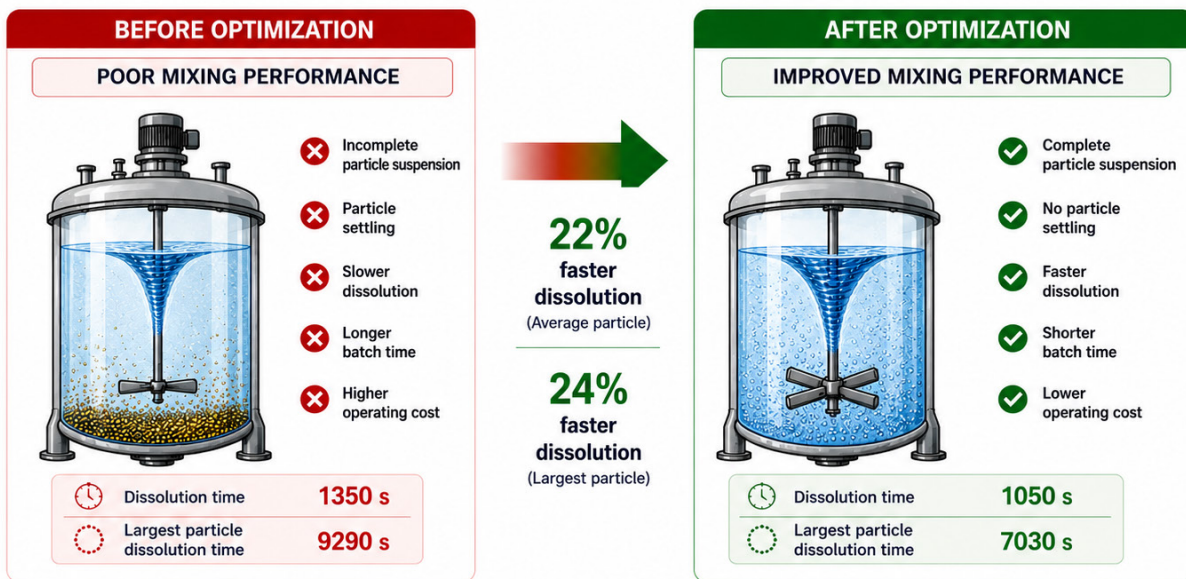
## CONCLUSION

- This case study demonstrated that optimizing the impeller geometry significantly improved the dissolution process by achieving complete particle suspension and improving the conditions for liquid-solid mass transfer. The optimized mixing system reduced the dissolution time without changing the operating conditions.
- The study highlights the importance of understanding mixing hydrodynamics during process design and demonstrates how appropriate impeller selection can improve dissolution performance, process consistency, and overall manufacturing efficiency.

Please refer: [Dissolving of Solid Particles](#)

# Better Mixing Design. Faster Dissolution. Greater Efficiency.

*Optimize impeller geometry. Achieve complete suspension.  
Reduce dissolution time without increasing speed.*



 Optimize impeller geometry	 Achieve complete suspension	 Improve mass transfer & dissolution	 Reduce cost & increase productivity
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Smart mixing design today leads to **better performance tomorrow.**  
Simulate with VisiMix and make every batch count.



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