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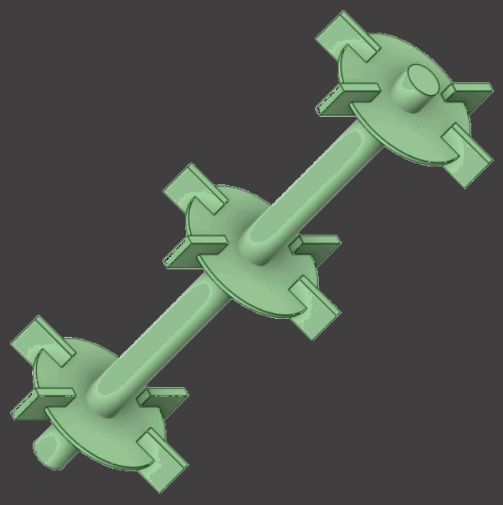
CASE STUDY · MED TECH

STIRRED-TANK BIOREACTOR

MULTIPHASE MIXING CFD · CAD & MESH SETUP
WITH NEXUS & ANSYS

Tools Nexus · Ansys SpaceClaim · ANSYS Fluent
Outcome 30% engineering time saved · built using natural language



WHAT'S INSIDE

A walk-through of how Nexus took a 1.5 L Rushton-turbine bioreactor from a natural-language spec to a solvable, self-verified multiphase CFD case: building the geometry, carving three MRF zones, meshing the vessel, and confirming the first flow physics, with the converged mixing results set up to follow.

Summary P. 03

A 1.5 L vessel built from a conversation: nine bodies, a conformal four-zone mesh, and the expected double-loop impeller flow at first look.

Problem P. 03

Cells need vigorous mixing for oxygen, but that same mixing shears them, and the geometry that balances the two is unforgiving to model.

Methodology P. 04

Across geometry, meshing, and physics, Nexus proposed the setup and waited for the engineer's input on every modeling call.

Results P. 05

Agent-built geometry, meshes, and the impeller's recirculation at an interim checkpoint.

Agent Design Input P. 06

Verified its own work, and flagged the limits before a converged kLa.

Try Nexus P. 07

How to bring the same workflow to your own bioprocess and mixing CFD studies.

SUMMARY

A full multiphase bioreactor CFD case, built from a conversation. Geometry to a solvable mesh, self-verified at every step, and set up for the mixing study.

Nexus built a 1.5 L Rushton-turbine bioreactor (tank, shaft, three impellers, four baffles) inside Ansys SpaceClaim from natural-language instructions, **verifying its own geometry by volume** before saving and carving the fluid into a **conformal four-zone MRF mesh** Ansys Fluent could solve on. The agent also **checked its actual output at each step** rather than trusting the tool's status, re-running a mesh step that had come back empty before moving on. An interim solve already shows the **expected double-loop recirculation** of a working radial-flow impeller. The takeaway: a complete, self-checked multiphase setup came out of natural language, with the converged mixing results a solve away.

30%
ENGINEERING TIME SAVED

9
BODIES BUILT FROM NATURAL LANGUAGE

4
CONFORMAL CELL ZONES, ONE MESH

PROBLEM

A bioreactor has to satisfy two needs that fight each other: cells need dissolved oxygen to grow, and the only way to drive in enough oxygen is vigorous mixing, the same mixing whose shear can damage or kill the cells it feeds.

01 **kLa is set by the flow, not a formula**

The oxygen-transfer coefficient depends on bubble size, interfacial area, and local turbulence, all governed by the specific field three impellers create. Once the geometry gets specific, a spreadsheet correlation can no longer see it.

02 **The setup is delicate and unforgiving**

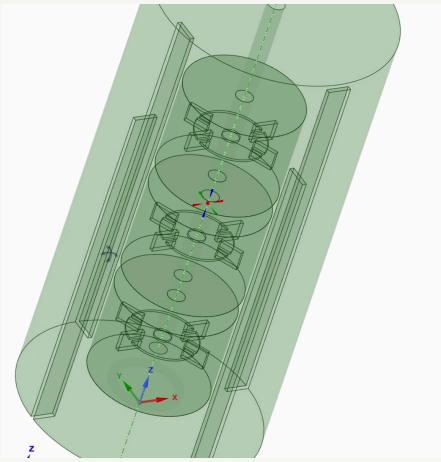
A multiphase, multi-impeller MRF case turns on modeling calls a spec sheet cannot settle (baffle mounting, sparger idealization, the number of rotating zones), and on getting gas-liquid multiphase and species-transport physics to converge on top of three rotating frames.

+ Benefit to engineer

Every entity the agent builds (each impeller, baffle, MRF zone, and mesh control) stays individually named and editable, and the agent checks its own work at each step. The case is a glass box, not a black box: inexpensive to iterate on and safe to build on.

METHODOLOGY

The vessel came together as a collaboration. From a parameter table (tank, shaft, three Rushton impellers, four wall baffles, the standard layout for a tall bioreactor), Nexus carried the unambiguous build steps and surfaced every open modeling choice for the engineer to decide.



REACTOR FLUID DOMAIN · 1.5 L · 3 RUSHTON IMPELLERS (D/T 0.4) · 4 BAFFLES (T/10) · 3 MRF ZONES · H/T 1.5

SETTING	VALUE	
Impeller motion	MRF, steady · three rotating zones, one per impeller (1.25× D)	
Multiphase model	Species transport with interphase mass transfer, gas–liquid	NEXUS
Sparger inlet	Torus surface as gas inlet · air enriched to 30% O_2 by mass	
Liquid phase	Culture broth: water, glucose, amino acids/salts, dissolved O_2 + CO_2	
Local mesh sizing	Impeller 0.6 · baffle 0.8 · sparger 0.6 · shaft 1.2 · wall 0.4–4 mm	NEXUS
Volume mesh	Poly-hexcore, Fluent Watertight Geometry workflow	NEXUS

+ What Nexus proposed

Nexus put forward the multiphase recipe, from the rotating-frame model to the per-part mesh sizing, the standard starting point for a mixing case like this.

+ What the engineer decided

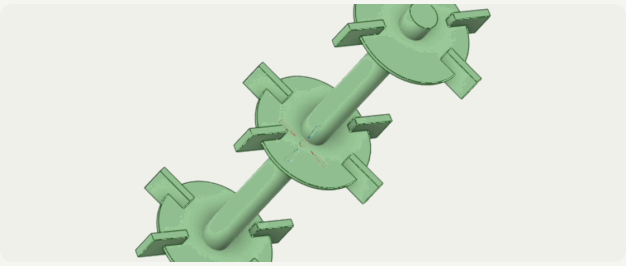
The calls a spec cannot settle (flush baffles, the sparger idealization, three MRF zones over one) went to the engineer, who reviewed each and signed off before the build moved on.

RESULTS

BUILD VERIFICATION

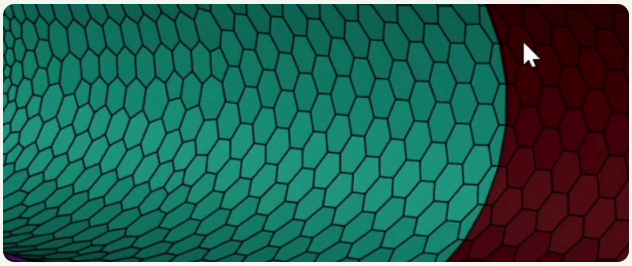
CHECK	EXPECTED	ACTUAL
Baffle volume	3,630 mm³ (11×2×165)	3.63e-6 m³ ✓
Bodies built	9	9, saved ✓
Conformal cell zones	4	4 (tank + 3 MRF) ✓
Volume mesh	poly-hexcore	1,612,703 cells ✓
Min orthogonal quality	> 0.1 (solver floor)	0.20, accepted ✓

The build saved roughly 30% of the engineering time versus a manual setup. Every figure below was generated by Nexus, in the order the build produced it: a verified geometry, a conformal surface mesh, the poly-hexcore volume mesh, and, once the solve was running, the flow field itself, with its cut-plane, vectors, and legends all sensible defaults Nexus chose from plain-language prompts. Read together they trace the case from a set of named bodies to a physically sane first look at how the impellers move the broth.



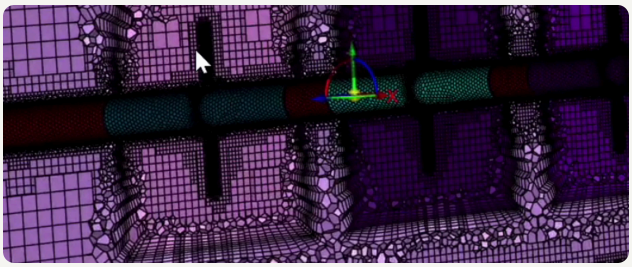
1 · The built vessel

Three Rushton impellers on one shaft, four wall baffles, and the sparger: nine bodies in all, each checked against the parameter table before the geometry was saved.



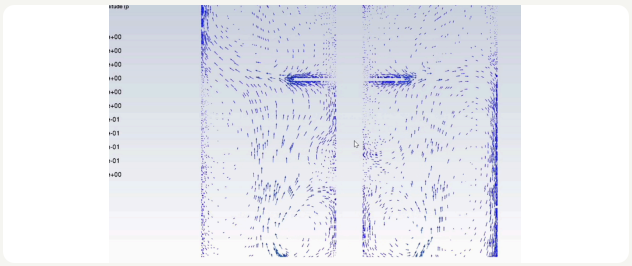
2 · The conformal interface

Where a rotating MRF zone meets the stationary fluid, the mesh matches node-for-node across the green interface: one conformal mesh, so velocity hands off without interpolation error at the blade tips.



3 · Poly-hexcore volume mesh

Hexahedral cells fill the open bulk in regular rows while polyhedral cells absorb the complexity around the shaft, disks, and baffles: 1.6 million cells without a punishing tetrahedral count.



4 · Impeller flow at an interim checkpoint

Velocity vectors on a cut plane. The Rushton discharge strikes the wall and splits into two counter-rotating loops, the textbook double-loop recirculation, clear even before full convergence.

AGENT DESIGN INPUT

Nexus built the CAD and mesh setup from natural language and checked its own work at each step. This page covers what it caught, the limits it flagged itself, and how it can carry the case to converged mixing results.

What the agent caught

The first volume mesh reported “up-to-date” but had actually built nothing. Rather than trust that status, the agent checked the real cell count, caught the empty result, and re-ran the step: 1.6 million cells, four cell zones, no human input needed.

! Fidelity caveat, flagged by the agent first

Nexus checks the physics as it builds and solves the case, flagging what isn’t trustworthy yet so a weak setup surfaces early rather than after a long converged run. What it flags here: this is an interim solve, not a converged result, on a single mesh with no independence study yet. The impeller is modeled as quasi-steady (MRF) and the sparger as one ring inlet rather than the individual bubbles that ultimately set kLa, and the mesh’s minimum orthogonal quality is 0.20, at the low end of Fluent’s comfort range and worth watching. The geometry, mesh, and interim flow all hold, and Nexus can carry the study forward through the further steps to kLa.

A **Built from natural language**

A multiphase case like this is normally hours of manual GUI setup. Nexus built the whole thing, nine named bodies, three MRF zones, a conformal mesh, and the gas-liquid physics, from plain-language instructions, so the engineer’s time goes to judgment calls.

B **Agentic self-verification**

The agent verified its own output rather than trusting a status flag, checking baffle volume against the analytical 3,630 mm³ before saving. Because every entity is named (impeller-facesize, MRF_1, Baffles), any one stays a single-control edit, not a rebuild.

→ Next steps and Nexus

The build is done. What remains is running the steady-state solve to full convergence and extracting the mixing results this study was set up to deliver. Because the case is already built, named, and verified, Nexus can run the converged solve on the existing setup, along with any mesh refinement the orthogonal quality calls for, as edits rather than a rebuild.

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Think through > click through. Let Nexus handle the rest.

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