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Towards High-Order CFD-DEM: Development and Validation

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Supporting Information for Publication

Table S1: Physical and numerical parameters for the particle sedimentation test case.

Simulation control			
End time (s)	0.5		
Coupling frequency	10^2	CFD time step (s)	10^{-3}
Geometry			
Bed Height (mm)	100	Bed Radius (mm)	50
Wall Thickness (mm)	0	Mesh Type	dealii::subdivided-cylinder
Mesh Refinement	1	Mesh Subdivisions in x	5
Particles			
Number	1	Diameter(m)	2×10^{-3}
Density(kg/m^3)	2500	Young Modulus (N/m^2)	1×10^6
Particle-particle poisson ratio	0.3	Particle-wall poisson ratio	0.3
Particle-particle restitution coefficient	0.2	Particle-wall restitution coefficient	0.2
Particle-particle friction coefficient	0.1	Particle-wall friction coefficient	0.1
Particle-particle rolling friction	0.2	Particle-wall rolling friction	0.3
Gas phase			
Viscosity ($Pa \cdot s$)	1.005×10^{-6}	Density (kg/m^3)	997
Inlet Velocity (m/s)	0	Void fraction smoothing factor L^2	0
Linear Solver			
Method	GMRES	Max iterations	5000
Minimum residual	1×10^{-11}	Relative residual	10×10^{-3}
ILU preconditioner fill	1	ILU preconditioner absolute tolerance	1×10^{-14}
ILU preconditioner relative tolerance	1		
Non-linear solver			
Tolerance	1×10^{-9}	Max iterations	10

Table S2: Physical and numerical parameters for the fluidized bed test case.

Simulation control			
End time (s)	5	Time discretization scheme	BDF1
Coupling frequency	10^2	CFD time step (s)	10^{-3}
Geometry			
Bed Height (mm)	400	Bed Radius (mm)	10
Wall Thickness (mm)	0	Mesh Type	dealii::subdivided-cylinder
Mesh Refinement	2	Mesh Subdivisions in x	40
Particles			
Number	2×10^5	Diameter(m)	5×10^{-4}
Density(kg/m^3)	1000	Young Modulus (N/m^2)	1×10^6
Particle-particle poisson ratio	0.3	Particle-wall poisson ratio	0.3
Particle-particle restitution coefficient	0.9	Particle-wall restitution coefficient	0.9
Particle-particle friction coefficient	0.1	Particle-wall friction coefficient	0.1
Particle-particle rolling friction	0.1	Particle-wall rolling friction	0.1
Gas phase			
Viscosity ($Pa \cdot s$)	1×10^{-5}	Density (kg/m^3)	1
Inlet Velocity (m/s)	[0.02-0.28]	Void fraction smoothing factor L^2	1.25×10^{-6}
Linear Solver			
Method	GMRES	Max iterations	5000
Minimum residual	10^{-10}	Relative residual	10×10^{-3}
ILU preconditioner fill	1	ILU preconditioner absolute tolerance	10^{-14}
ILU preconditioner relative tolerance	1-1.1	max krylov vectors	1000 | 2000
Non-linear solver			
Tolerance	1×10^{-9}	Max iterations	10

Table S3: Physical and numerical parameters for the setup of the spouted bed test case.

Simulation control			
End time (s)	20	Time discretization scheme	BDF2
Coupling frequency	100	CFD time step (s)	5×10^{-4}
Geometry			
Bed Height (mm)	1000	Bed Width (mm)	280
Bed Depth (mm)	40	Wall Thickness (mm)	0
Channel Height (mm)	40	Channel Width (mm)	24
Channel Depth (mm)	40		
Mesh			
Mesh Type	gmsh		
Bed Subdivisions in x-y-z	36-100-4	Channel Subdivisions in x-y-z	2-5-4
Particles			
Number	175800	Diameter(m)	25×10^{-4}
Density(kg/m^3)	2500	Young Modulus (N/m^2)	1×10^7
Particle-particle poisson ratio	0.25	Particle-wall poisson ratio	0.25
Particle-particle restitution coefficient	0.9	Particle-wall restitution coefficient	0.9
Particle-particle friction coefficient	0.3	Particle-wall friction coefficient	0.3
Particle-particle rolling friction	0	Particle-wall rolling friction	0
Gas phase			
Viscosity ($Pa \cdot s$)	1.81×10^{-5}	Density (kg/m^3)	1
Inlet Velocity (m/s)	20.8		
Linear Solver			
Method	GMRES/AMG	Max iterations	1000/100
Minimum residual	10^{-8}	Relative residual	10^{-2}
ILU preconditioner fill	1	ILU preconditioner absolute tolerance	10^{-10}
ILU preconditioner relative tolerance	1	max krylov vectors	200
Non-linear solver			
Tolerance	1×10^{-9}	Max iterations	25